TOPICS OF THE MONTH

Non-' N '

THE laws governing the flow of non-Newtonian fluids, which crop up in such diverse forms as drilling muds and toothpaste, and include also many important plastic materials, rubber solutions, paints, clay suspensions, foodstuffs such as mayonnaise and liquid chocolate, and industrial slurries and emulsions, are the subject of much interesting research by rheologists, but to the chemical engineer a real move to establish the precise pattern of behaviour of such fluids is long overdue. Some day, it is hoped, someone will evolve a reliable general equation for the calculation of non-Newtonian fluid viscosity and thus earn the undying gratitude of countless plant designers. For non-Newtonian flow is a problem that is met with not only in the design of pipeline systems and heat exchangers but also in such operations as mixing and, although there has recently been more progress in work on the mixing of pastes and suspensions (D. F. Riley, CHEMICAL & PROCESS ENGINEERING, 1959, **40** (2), 45), co-operation between chemical engineers and physicists on this subject has not been noticeably sustained or fruitful.

The issue is confused by conflicting notions as to the nature of non-Newtonian fluids and the correct mathematical approach to dealing with them. One welcome contribution to clearer thinking on the subject is a paper by Dr. D. R. Oliver in the *Birmingham University Chemical Engineer* (1958, **10** (1), 20) which bravely attempts a firm definition and classification of non-Newtonian materials. Dr. Oliver divides these materials into (*a*) time-independent fluids, in which the shear stress is a function of the rate of shear and nothing else; (*b*) time-dependent fluids, in which the shear stress rate of shear relationship is a function of time of shear or the previous history of the sample; and (*c*) viscoelastic fluids in which the property of elasticity is added to the usual viscous properties of the fluid. These broad groups are again sub-divided into a number of smaller groups. Dr. Oliver goes on to present formulae for the volumetric flow-rate of time-independent, non-Newtonian fluids in tubes of circular cross-section, and also equations for a more general approach to pipeline design.

Some interesting contributions of the rheologists to a better understanding of plastic flow are outlined in a paper which was presented to the Royal Society of Arts recently by Dr. E. G. Richardson and Dr. G. W. Scott-Blair. The problems of rolling dough in bakery operations, the 'spreadability' of butter and cheese and the viscosity of biological secretions in animals (measurement of which can yield important data about the physiological condition of the animal) are subjects which come within the range of this branch of science. And, to come back to chemical engineering, so does the conveyance of powders in fluidised beds, where we have an example of a fluid in which, instead of the matrix being liquid, a gas, usually air, carries particles in suspension.

In case all this was not sufficient to convince us that rheology is much more of a 'dark horse' than we suspected hitherto, and that the subject is not locked up in obscure and rather eccentric laboratory tests, we are hurled into the universe at large with the observation that the peculiar geological formations at the Giant's Causeway in Ireland have been ascribed to rheological flows 'frozen' into position in past ages. The subject of magneto-hydrodynamics, which deals with the interaction between magnetic fields and viscous flows in, for example, the sun, is also a branch of rheology.

It is reflections like these that make us more and more conscious of the fact that all paths in science lead to the same end—let us hope that, unlike the subjects of rheological experiments, it will not be a 'sticky' one. Probably we shall never know enough about non-Newtonian fluids until all chemical engineers and rheologists are one with the chemists, physicists, biologists and all the other 'ists' in this restless, ignorant world.

Chemical exports at the crossroads

OVER all the hopes, anxieties and fears about world trade in the future and the future pattern of exports from the major European countries looms the shadow of the industrial developments now taking place in the Soviet Union and China, whose exportation of chemicals, for instance, is growing steadily and making a considerable impact on countries such as India and South Africa. In a speech he made during a presentation to the Stalinogorsk Chemical Works (see 'World News') Mr. Khrushchev told his audience that the U.S.S.R. is now the biggest producer of chemical goods in Europe and the second biggest in the world, and prophesied that in 1965 it will approach the U.S.A. in the production of key chemical products. Noting that the programme for rapid development of the chemical industry was being steadily and consistently carried out, he urged still further efforts to step up development and the maximum use of the cheapest raw materials, oil and natural gas. At the same time he advocated a greater co-ordination of effort between Soviet chemists and related scientists and those in Eastern Germany and other countries within the Soviet sphere.

The fear that competition from the Soviet Union and China may be Britain's most serious problem in future was expressed by Mr. S. P. Chambers, C.B., deputy chairman of Imperial Chemical Industries Ltd., in a recent address to the Plastics Institute, when he pointed out that it was no longer sufficient to shrug off competition in the chemical field from countries like the U.S.S.R. and China with the theory that the need to get foreign exchange will from time to time lead

these countries to export some of their production regardless of cost. It is no longer clear that this glib explanation is sound. It is perhaps comforting, Mr. Chambers said, to persuade ourselves that we are more efficient and lower-cost producers of chemicals than the Russians or the Chinese, but it is doubtful whether this assertion can be supported with concrete evidence. Indeed, an investigation of the facts might reveal that costs in these countries are lower than in our own, and that these exports are not so uneconomic as we would like to believe.

Looking at the picture from another side, Mr. Chambers commented that, with the relatively low standard of living in Russia it is possible that the emphasis on heavy and semi-heavy industry may at present lead to a surplus of production in these industries for which there is no immediate demand at home and which might, therefore, conveniently be exported. In this way intermittent floods of chemicals from these countries might be experienced and the prices charged might or might not bear some relationship to the cost of production. In India the appearance of substantial quantities of soda ash of Chinese origin in one year but not in another is an indication that in China there may be capacity which gives an exportable surplus from time to time.

However, neither in the U.S.S.R. nor China can the process of industrialisation go on indefinitely without substantial increases in the standards of living there. As standards of living rise and the industries become more complex there will probably be a growing need to import products, including chemicals, which are not manufactured, or are not manufactured in sufficient quantity, at home. We may, therefore, see an upsurge of imports of chemicals into the U.S.S.R. and China balancing or more than balancing their chemical exports.

Here there is an opportunity for the British chemical industry, for, as Mr. Chambers points out, there has in the past been too much dependence on the overseas sterling markets and the aim should be to expand considerably, if possible, exports to the Soviet Union and her fellows, because of the growing needs of their capital and consumption industries. With this, he feels, there should be an effort to increase exports to all those miscellaneous markets which lie outside the United States, Western Europe and the sterling area.

On the broader aspects of international trade, Mr. Chambers pointed to the trend for the proportion of exports to industrialised areas to grow, and the proportion going to non-industrialised areas to decline. Except for the rehabilitation of Germany, with her re-entry into world export markets, and the rise of countries like Japan, the proportions of world trade in chemicals held by the major countries have not changed very radically in recent years, although those of the United Kingdom and France have tended to decline while those of certain other countries have gained somewhat. Europe is easily the largest export market for chemicals, taking more than a third of the total free-world chemical exports, and is also one which is expanding rapidly. Unfortunately Britain's share in this market is small compared with those of Western Germany and the U.S.A., and her chemical exports go to the small markets which are not expanding rapidly, such as the British Overseas Territories and the rest of the sterling area. These areas, Mr. Chambers said, were in some respects unreliable markets, while there were certain formidable obstacles to any substantial sale of British chemicals to the U.S.A. or Canada; hence the need to explore new markets.

Mechanical power from vaporising liquid gas

GASES such as oxygen, nitrogen or methane are usually transported or stored in large quantities in their liquid state. The refrigeration available in these liquid gases is destroyed when the gases are vaporised into pipelines for supplying industrial plant—heat, either from an electrical store or from steam, usually has to be supplied for this purpose. A new process has now been developed which makes it possible to utilise this refrigeration to produce mechanical energy. Gas is compressed in the liquid state to a pressure well above that required at the gas delivery point. A natural heat store, such as the atmosphere or a river, supplies heat to the liquid gas which is then expanded in a turbine or reciprocating expander. The expanded gas is then further warmed to about room temperature by means of the natural heat store.

According to British Oxygen Research & Development Ltd., who have patented this process, the work required for the purpose of compressing the original liquid will only be a small fraction of the total produced in the expansion engine and the balance will be available as free mechanical power. This can be used for any suitable purpose, *e.g.* for the production of electrical energy.

Taking a firm's stand

THE responsibility for organising a conference, a technical meeting or an exhibition stand is often thrust upon a sales or technical executive who, though eager and willing to do his best, has limited ideas as to how the job should be tackled. He is frequently unaware that a fund of 'know-how' has been built up which, if drawn upon, can save a great deal of frustration and wasted effort. A periodical which brings together the latest techniques for organising exhibitions and conferences is undoubtedly a boon to all who are faced with such problems and in this respect our associate journal *Conferences & Exhibitions* (incorporating *The Sales Executive*) has been doing commendable work. This virile publication always has something interesting and useful to say and the popularity it has achieved since it started only two years ago is proof that it is filling a long-felt need.

In the March issue an article by Mr. E. N. Simons pays particular attention to the problems of organising a stand at a technical exhibition. He urges extreme caution in considering invitations to participate in exhibitions and advocates that each proposal should be considered as if it were an invitation to take advertisement space in a particular journal. But there are

certain differences between the purchase of exhibition space and the purchase of advertisement space. Thus, unless the exhibition is strictly technical, it is bound to attract a large number of mere sightseers. Unless the goods exhibited have a wide popular appeal, these people are, to the maker of technical products, the equivalent of 'waste circulation' in a journal. Whereas, however, the 'useless' readers of a journal or newspaper do not interfere with the ability of the directly interested readers to receive his message, the presence at an exhibition of a large number of mere sightseers can, and usually does, interfere considerably with the ability of a legitimate buyer to see the exhibits that interest him. He is likely, therefore, to see less than he would if the exhibition were of purely technical interest. The manufacturer contemplating the taking of a stand must bear all this in mind.

The article goes on to give some useful hints on the design and positioning of the stand and is typical of the informative contributions that appear in *Conferences & Exhibitions* every month. The journal costs 25s. p.a. and further information can be obtained from the publishers at 9 Eden Street, London, N.W.1.

Mixed blessings

'GOING around a factory recently,' remarks 'Cicerone' in *The Manufacturing Chemist*, apropos of mixing operations in the pharmaceutical industry, 'I heard complaints of mechanical faults which I would have thought would long ago have been eliminated.' Pointing to a newish-looking paddle mixer, the factory manager said it did a perfectly good job except for one thing: it leaked grease into the mix—not much, but enough to disperse into a thousand particles that eventually showed up as spots on the tablets being produced there.

Seems to us that, given that this was due to an inherent fault in the design of the machine and not to the way it was installed or serviced, this points to (*a*) a useful field of investigation for firms supplying mixing machinery to the pharmaceutical industry, or (*b*) research by petroleum chemists to discover a grease that is beneficial to human health (if this has not already been done by pedlars of patent medicines).

But to return to 'Cicerone,' he comments on another curious fact: although safety devices are built into mixers with internal agitators to prevent accidental ingress, apparently there are no rules against using a rotating mixer uncaged. Of course, he says, any decent firm naturally puts it into a cage immediately and adds a trip device to prevent it being used when the cage is open. But there are factories in this world with less refined ideas. Odd, says 'Cicerone.'

Being one with H.M. Inspector of Factories in the matter of industrial safety we can only endorse the sentiments which lie behind this criticism. But, having been round a few factories ourselves, we can only say that if 'Cicerone' is surprised at such practices he is not quite the man of the world his sparkling monthly comments have hitherto led us to believe.

From filmwise to dropwise

THE use of chemical compounds to promote dropwise condensation in heat exchangers and thus improve heat-transfer rates in industrial steam and other condensing plants seems to offer promise of substantial savings if present development work bears fruit. Various aspects of the subject are being studied at the Mechanical Engineering Research Laboratory (D.S.I.R.) at Glasgow, including the life expectancy of various promoters on different metal surfaces when condensing pure and industrial steam. An article by T. B. Fielden in our December 1957 issue discussed the use of filming amines for promoting dropwise condensation.

In tests carried out with various water-repellent compounds in copper and copper alloy condenser tubes, it has been found that the promoter can either be injected into the steam supply or manually coated on the condenser tubes. The thickness of the coating has to be very small, preferably only a few molecules, to avoid loss of heat transfer. The big snag has been to find a promoter having prolonged stability.

According to a recent article in the Copper Development Association's journal, the ideal promoter should be a compound of (*a*) a water-repellent group, *e.g.* a hydrocarbon of high molecular weight, and (*b*) a group having a high affinity for the metal to be treated. For the treatment of copper-base materials, a large number of organic compounds with groups containing sulphur or selenium atoms, both of which have a high affinity for copper, have been developed and tested in the U.K. These compounds, manually applied to tubes of copper and copper alloy, were found to maintain satisfactory dropwise condensation for periods ranging from 500 to 4,000 hr.

In a second series of tests a 1% solution of the promoter in a suitable low-boiling solvent, such as ether or carbon tetrachloride, was injected into the steam supply. To convert the mode of condensation from filmwise to dropwise the promoter must penetrate the existing film of condensate and then adheres to the surface. The injected compounds which were either wholly or partly miscible with water had the effect of instantly changing the condensation from filmwise to dropwise. With some of the compounds of higher molecular weight, several injections were required before a complete change was obtained. This was possibly due to the inability of these larger molecules to penetrate the existing film of condensate. During the testing of these particular compounds, it was observed that, although the transformation from filmwise to dropwise was slow to commence, once a small area of tube exhibited dropwise condensation this rapidly spread over the whole surface. Consequently, for industrial condensing plants, it seems likely that, where either filmwise or mixed condensation exists, this could be converted to the dropwise form by the injection into the steam supply of a suitable promoter.

In view of the small quantity of promoter required to cover the metal surface with a monomolecular

layer, it is believed that any contamination of the condensate is unlikely to have any adverse chemical effect in the steam generating system. However, where repromotion by injection into the steam may be used, the cumulative effect would have to be carefully studied.

Against corrosion

ADVANCE reports on the exhibits to appear at the Corrosion Exhibition, which is being held in London from the 27th to the 30th of this month, provide striking evidence of the ubiquity of the corrosion problem and of the ingenuity of scientists and technologists in devising ways to combat it. One of the most valuable functions of this exhibition is that, not only will it reveal the wealth of anti-corrosion techniques now available, but it will also provide the engineer and industrialist with the means of finding out where and how they should be used. For the aim of anti-corrosion measures is to protect plant, equipment and products and so save money; misapplied, they only waste money and defeat their object.

Thus, one invaluable product of modern research is volatile corrosion inhibitors, but they can give disappointing results if used indiscriminately. They may protect certain metals in some contaminated atmospheres but not in others. At the Corrosion Exhibition, the Corrosion of Metals Group of the National Chemical Laboratory, Teddington, will show a preliminary research experiment which reveals variation in the protection given by cyclohexylamine carbonate (CHC) to steel surfaces grossly contaminated with various salts and exposed to a humid atmosphere. On the same stand, an illustrated description will be given of the type of water-circulation system that is being used to investigate the corrosion of metal plates by flowing water at various temperatures. The results should be of value in predicting the behaviour of metals in hot-water systems and in heat exchangers generally. A further objective is to develop inhibitors that will be effective at concentrations of 10 p.p.m. or less.

The engineer who is more interested in what is available *now* for handling corrosive media will no doubt focus his attention on items such as the *Rayon-Patent* valve, developed in Holland for the control of corrosive fluids and gases, and now being produced in Germany and the U.K. This is to be on show with various alternative body linings. The corrosion engineer with pipeline protection problems on his mind will find, on one stand, an interesting display devoted to the subject, with instruments for all aspects of corrosion survey work and the design of cathodic protection systems. One point not to be overlooked where chemical solutions are to be applied for combating corrosion is that small, accurate pumps will be required. An electrically operated pump is to be shown with a maximum capacity of 50 gal./day against a pressure of 125 p.s.i. and a power requirement of only 40 watts.

Those interested in corrosion-resistant coatings will find plenty to interest them at the Corrosion Exhibition, for there will be displays of coatings for the protection of plant, steelwork, floors, etc., while at the other end of the scale an organisation which places emphasis on metallic coatings for the protection of materials under all sorts of conditions will give a very comprehensive picture of its research and consulting activities.

These few examples, taken at random, will suffice to show that the Corrosion Exhibition will be well worth the attention of all concerned with the fight against corrosion, which means all engineers and executives in industry today.

A limited number of complimentary tickets are still available to readers of CHEMICAL & PROCESS ENGINEERING and these can be obtained on application to the editorial department at Leonard Hill House, Eden Street, London, N.W.1.

Break-through in antibiotics

THE successful isolation of the basic molecule of penicillin, with the discovery of a new substance, 6-amino-penicillanic acid, is an achievement which will be applauded by organic chemists all the world over, and should lead to a considerable advance in the field of antibiotics and in medicine. It will make possible the synthesis of innumerable new penicillins, thus breaking the stalemate reached in medical practice in the treatment of cases where existing penicillin substances are ineffective.

Further microbiological research will be needed to exploit the discovery as quickly and fully as possible, and the Beecham Group, in whose laboratories the discovery was made by four young research workers, hint at a forthcoming announcement about research and development co-operation with a large American company in the antibiotic field.

Dr. J. Farquharson, director of research at the Beecham laboratories, recalls how, in their search for new antibiotics, they sought as a starting point to produce by conventional fermentation methods a penicillin amenable to chemical modification, after fermentation, into new and unknown penicillins. The most commonly used penicillin, G, is not susceptible to modification. It proved a lengthy and laboursome operation, since most of the chemical precursors were not accepted by the moulds. It took the microbiologists the best part of a year to work out the conditions for the mould to produce one modifiable penicillin and to extract a small quantity for the chemists to work on.

In the course of their work the microbiologists used the two conventional methods of assay, microbiological and chemical. Normally these two methods confirm one another. Under certain conditions, however, the microbiologists noted consistent discrepancies between the results of the two methods, for which there was no explanation in the current state of knowledge. They took the problem to the chemists. A deduction was made that the brew contained an intact penicillin-like material, most probably just the core of the penicillin molecule, *i.e.* 6-amino-penicillanic acid. The proof of this deduction was to treat the brew chemically with the right reagent and produce penicillin G.

So they went right ahead and did it.

CHEMICAL PUMPS

A COMMENTARY ON CURRENT PROGRESS AND PROBLEMS

By W. F. Riester, Dr.Ing., M.I.Mech.E.

This article summarises the advances that have been made by pump manufacturers in providing the special features necessary for chemical pumping duties and discusses briefly some notable developments as well as some needs which have not yet been satisfactorily met.

IN recent years there has been a significant commercial development in the pumping field. Some manufacturers in Britain, having noted the existence of a large and growing market, are now offering a range of pumps, which are advertised as 'chemical pumps.' Such pumps, of the centrifugal single-stage type, are now made in batches for stock, mostly in 18/8 stainless steel, and can therefore be supplied at very reasonable deliveries and prices. Manufacturers in Britain thus follow the trend in the U.S.A. and Germany where a number of pump makers have for some time catered exclusively for the demands of the chemical and process industries with complete ranges of stock-produced pumps.

There have also been, of course, quite a number of makers in Britain who took pride in offering chemical pumps, but their ranges were limited and restricted to special materials, such as silicon iron, stoneware, rubber, plastics, etc., or they consisted of only a few types of very special construction.

It would appear that in all Europe there is only one manufacturer, in Germany, who consistently for over 40 years has supplied pumps to the chemical industry only on a large batch production basis and who refuses to quote for water pumps. It is evident that a wealth of most valuable experience is bound to accumulate in any such firm supplying tens of thousands of chemical pumps over many years, which again by necessity must have been accompanied by misapplications, disappointments and troubles.

One may look forward to the day when in Britain, too, a manufacturer will abandon water pumps and will concentrate solely on properly designed chemical pumps. Up to only a few years ago, a pump made of materials other than cast iron or bronze was termed 'special' by a maker who predominantly dealt with water-pumping problems, with all the disadvantages—both for maker and user—resulting from such treatment as a 'special.'

Features of a chemical pump

If there is such a thing as a 'chemical' pump, what are its features? Surely it cannot be satisfactory simply to use a design developed for pumping water and make it of corrosion-resisting materials. Books published dealing with pumps are not very explicit on this matter. The following features may be set down:

(*a*) Simplicity of design.
(*b*) Suitable materials for wetted and other parts.
(*c*) Minimum of leakage points (joints or glands).
(*d*) Capability of dealing with vapour and solids inclusions.

The above apply to all types—centrifugal, reciprocating and rotary—and are dealt with in more detail below.

Simplicity of design

This refers mainly to simple patterning, to facilitate casting of difficult materials. Hydraulic and mechanical efficiency may have to be sacrificed. Open or semi-open impellers are preferable to fully shrouded types. Machined surfaces should be a minimum, as should also the number of components. A maximum number of parts should be interchangeable in a range of pumps, *i.e.* three or four different casings should fit one bearing pedestal, with shafts, sleeves, glands, and impeller nuts the same for all types of this group. This will reduce stocking of spares and ensure quick servicing. All parts should be easily accessible by a few quick manipulations. Many makers supplying the chemical industry now provide pumps with all, or some, of these features.

Use of suitable materials

Corrosion problems in pumps are often of a complex nature. Not only the liquid pumped and its temperatures, but often also the concentration and presence of oxidising agents, such as air, steam or others, must be taken into account.

The primary factor controlling corrosion is the tendency of the metals to dissolve electrolytically in the solution pumped. Surface homogeneity is next in importance, *i.e.* avoidance of cracks, scratches, inclusions, rough machining marks, etc. Also the ability of the metal to generate a self-protecting film is of great value. Other factors are involved, such as hydrogen ion concentration, oxygen distribution on the metal surface, the effect of high velocities along the surfaces, impurities present, stress variations in the metals, etc.

A most valuable guide, known to every engineer, is the *p*H scale, which at least gives a first indication of metals not to be used. Also the galvanic scale of metals should be ever present in mind. Not only should the metals used be close together in this scale, but the area of the less noble metal should be large in comparison to a nobler metal used. Dissimilar metals should be insulated, if possible, or the less noble metal suitably coated. Aeration of the liquid should be prevented, or at least limited, and the hydraulic phenomena of cavitation entirely avoided.

Often a chemical inhibitor may help, such as chromates or alkalis, or replaceable pieces of bare zinc, or steel, may be fitted to counteract galvanic action. Less noble parts should be made easily replaceable and with a generous 'corrosion allowance.' It is also important that all metals should be of uniform and close grain, as often in the same basic metal dissimilar grain structure will form a galvanic

series and so initiate violent corrosion.

All this will show that corrosion problems are not always solved best by simply using stainless steels for all parts instead of less corrosion-resisting metals. In many cases, for instance, a chromium steel casing (less noble) which is less costly, with Cr-Ni steel impellers, will give better service than using nickel-containing steels indiscriminately.

Minimum of leakage points

This refers to joints in the wetted casing, which ideally should be reduced to one and be simple and circular, to ease maintenance.

A sore point to the chemical engineer—and often an eyesore as well—is the method of sealing around the rotating or reciprocating shaft. Increasing attention is given to this point and many special designs of chemical pumps have been evolved to improve or eliminate this shaft seal.

Stuffing boxes

The 'stuffing box'—the very name suggests primitivity—is still commonly used, though surprisingly undeveloped. It still consists of a space for the packing and a squeezing gland and basically has not changed since the beginning of pump engineering. Yet it is hard to believe that improvement should not be possible, and it is particularly desirable that a certain flexibility should be attained to enable the packing space to follow the inevitable shaft whip.

The very fact that a certain leakage has to be permitted to keep the packing in reasonable condition (by cooling and lubrication) has frustrated all efforts to improve it. The stuffing box is really unsuitable for a chemical pump, because many liquids handled in the chemical industry are either too dangerous, too corrosive, too toxic or too expensive to be allowed to be wasted.

Mechanical seals

From the oil industry has come the development of the mechanical seal, which today is almost universally used in that industry. It has now entered other fields, including the chemical industry, with conspicuous success. The chemical engineer, for good reasons, still harbours a good deal of scepticism about the mechanical seal. This is caused first by the great difficulty of finding the right materials for all its parts. Also they are awkward, when servicing is to be done, as complete dismantling is necessary to get at them. Lastly, they also require cooling and lubrication, which is either done by leakage (though smaller than with the stuffing box) or by external cooling and lubrication, which again may lead to contamination. Yet it must be admitted that vast improvements have been made possible by the introductions of mechanical seals.

In the U.S.A. one maker claims to be able to provide mechanical seals for pressures up to 2,500 p.s.i. and temperatures up to 650°F.

Pseudo glandless pumps

Attempts to avoid both stuffing boxes and mechanical seals have resulted in so-called 'glandless' pumps. These are either horizontal or vertical. They have no stuffing box or mechanical seals, but some other devices to improve leakage conditions.

The *horizontal* types are typified by the Rheinhuette RE and the *Wilfley* chemical pump. Here the essential feature is a ring valve around the shaft, which is kept closed, when the pump is stationary, by springs or weights acting on the shaft. When starting up, the valve is opened by movement of the shaft away from the seat, actuated by centrifugal force, and leakage is then prevented by appropriately dimensioned impeller back vanes or auxiliary impellers.

Such pumps have now been supplied in very large quantities over many years and must be accepted as a great step forward towards solving many leakage problems. As all things in life they have limitations. They should preferably be used with flooded suction, though suction lifts are possible. Suction pressures are limited by the back vane sizes possible, say up to 40 ft. according to shaft speed, but with an additional auxiliary impeller a further 25 to 30 ft. over this figure may be admitted. Back vanes and auxiliary impellers also consume power and thus reduce the overall efficiency. These pumps are, therefore, used mainly for low suction heads, but fortunately this covers the majority of chemical applications.

Vertical pumps with return line are also often called 'glandless,' which is only partly correct, because these pumps still have a gland, though it need not be packed unless it is necessary to prevent air ingress and/or fume leakage. This is often the case in diluted sulphuric acid service, for which they are frequently used.

The liquid is prevented from rising to the gland portion by a return line. The Kestner and the Rheinhuette GVS are typical designs of this type. Whilst they certainly improve the gland leakage problem, it is not always convenient to install a vertical pump. Their use appears, however, to be on the increase.

From Sweden has come the hydrodynamic seal which appears to have found ready application in the Scandinavian industry where it is used in sulphate and sulphite mills of the paper industry and also in sulphuric acid plants and other chemical works (phosphoric and nitric acids, sodium chloride and other brines). The hydrodynamic seal is a double-sided impeller working in a seal chamber on the pump suction end. One side of the impeller prevents the sealing liquid (usually the liquid being pumped) from entering the pump suction whilst the other side prevents the sealing liquid from escaping to the outside. A diaphragm valve acting against a shaft shoulder prevents leakage when the pump is stationary.

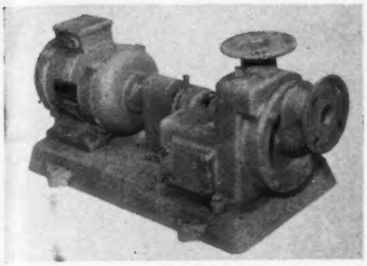
Pumps with this seal—called *Nobox* pumps—are always vertical. The sealing impellers must be designed for the suction condition applicable, but they are possible for 55 p.s.i. suction pressure or 24 in. Hg vacuum, which should be suitable for the majority of applications.

Genuine glandless pumps

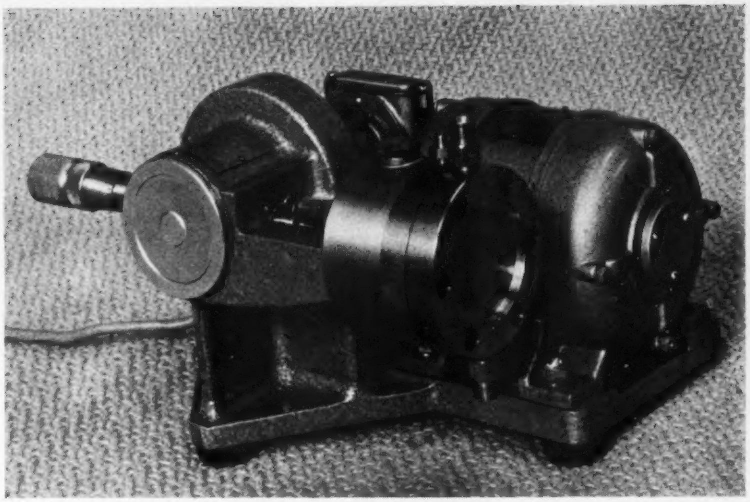
The latest step has been towards the completely sealed chemical pump. This can be (*a*) powered by an electric motor inside the pump casing, with the rotor operating in the liquid, in which case it is called a 'canned' motor pump because of the 'cans' protecting the rotor and the stator; or (*b*) conventionally powered and driven by magnetic coupling or a magnetic field acting through a section of the hermetically sealed casing.

Both these types are now commercially available and in operation and, although their prices are understandably higher than those for pumps with orthodox drives, it can be taken for granted that such units will be used on an ever-increasing scale.

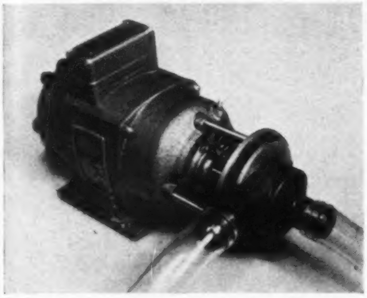
Submerged-motor pumps, for chemically neutral liquids such as water and oil, have been operated successfully for many years in borehole pumping and for circulation duties in boilers, transformers and heating systems. The 'canned' motor pumps were developed from these 'wet' motor pumps and in the nuclear industry in many cases no other pumps could be tolerated, as 'zero leakage' is imperative in that industry. The pumping of radioactive substances has therefore provided a great impetus, but it is certain that the general



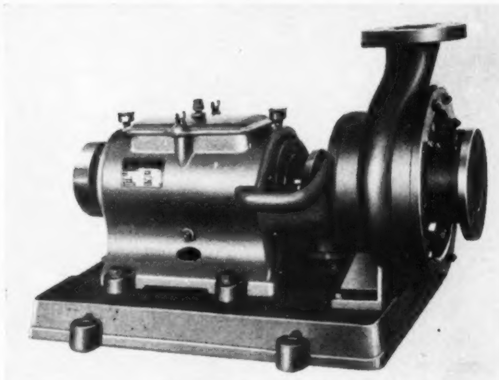
'Autostart' pump by Girdlestone Pumps Ltd., with open impeller of special form.



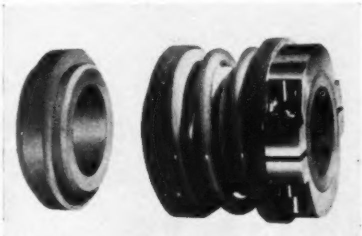
In this metering pump of The Distillers Co. Ltd. the diaphragm is actuated by a plunger pump, stroke variable by micrometer screws.



Polythene pump by Rediweld Ltd.: 5 gal./min., 7 ft. head, 1,450 r.p.m.

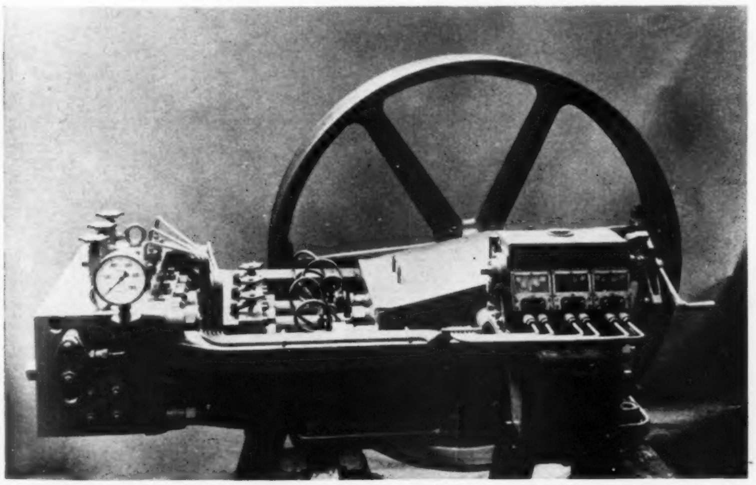


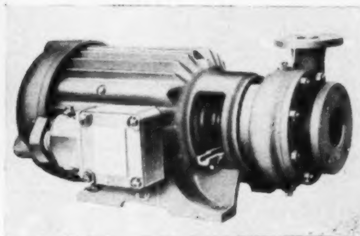
Rheinhuette 'RE' pump uses a ring valve operated by a centrifugal device (Conveyor & Equipment Co.).



'Fluon' PTFE mechanical shaft seal made by Crane Packing Ltd.

Vertical glandless pump by Rheinhuette (Conveyor & Equipment Co.).





Above. **Burckhardt liquid ammonia and carbon dioxide pump (Vernon Engineering Co. Ltd.)**

Right. **Worthington-Simpson Ltd. 'Monobloc' pump with flameproof motor.**

chemical industry will in due course benefit.

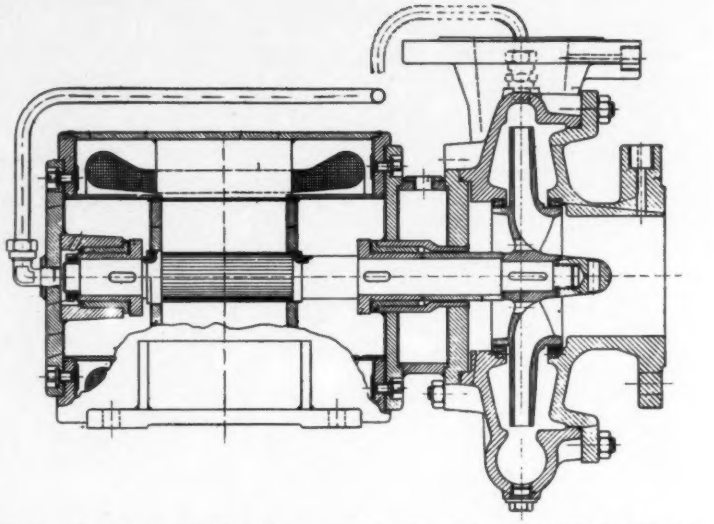
Whilst it appears that such pumps, for the chemical industry, are at present being developed in Britain, no commercial unit has yet been offered. Nuclear pumps of this type are, of course, available, but only in large sizes and for special duties. In the U.S.A., Germany and Switzerland, 'canned' chemical pumps are commercially available and quite a few types were exhibited at the last Achema Exhibition at Frankfurt in May 1958.

The use of 'canned' pumps in the chemical industry is still limited. Both manufacturers and users are proceeding with caution, but interest is widening and a few units are operating in the U.K. In the U.S.A. the demands of the nuclear industry have forced makers to design units of quite extraordinary size, pressures and temperatures. Pumps of this type are offered there for outputs from $\frac{1}{4}$ to 600 h.p. and for pressures up to 5,000 p.s.i., at temperatures to 700°F. In particular, pumps developed in the U.S.A. for liquid metals (sodium, lead, bismuth, etc.) are truly remarkable. Pumps of 40,000-gal./min. capacity for temperatures of 1,600°F. are available and some units supplied are for 3,400 gal./min., 700 h.p., at 1,500°F., and for 10,000 gal./min., 1,000 h.p. for liquid sodium, this latter pump having a total length of 29 ft.

It would, indeed, be surprising if the experience gained with such pumps were not in due course utilised in the chemical industry, where the need for them has long been felt, though the necessity for using them might not be quite so pressing.

Magnetic-coupling pumps (mentioned above), which are also 'zero leakage' types, will perhaps be used only for smaller outputs, as the design does not seem to permit economically the transmission of large magnetic forces. The limits are likely to be 10 h.p., though even this may be too high. They have, however, advantages over 'canned' motor pumps, because they have a wider temperature range, from −195°C. to +500°C.—and also system pressures may be up to 850 p.s.i. Such figures would be difficult to achieve with 'canned' motor pumps of simple design, though they can be made—at a price—as has been shown in the nuclear industry.

The nuclear industry has also been responsible for yet another type of 'zero leakage' pump, namely the electromagnetic pumps, which make use of the magnetic properties of the liquids pumped (sodium, bismuth, mercury). A.c. and d.c. conduction pumps are available and efficiencies of 40% have been reached when boosting up to 400 gal./min. They have neither glands nor any moving parts.



Typical section of a 'canned' motor pump for chemical duties (Halberg GmbH).

Dealing with vapour and solids inclusions

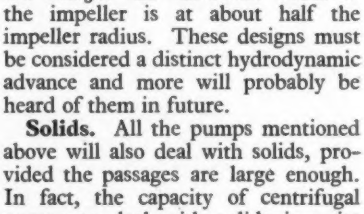
Vaporising liquids. The ability of a pump to deal with vaporising liquids is a very important feature which has not, in the author's opinion, been given sufficient attention. Discharge branches and casings should always be arranged to prevent vapour pockets, which is not always the case with pumps now offered. Some 'self-priming' centrifugal chemical pumps are now offered and such units can certainly deal with vapours and often with solids. The 'recirculation' principle necessitates, however, complicated and bulky casings which, when made of special materials, are costly.

Many applications do not in fact require self-priming, but only the capability of dealing with vapour inclusions. Typical cases are the pumping of mixtures, especially solid-liquid mixtures such as paper stuff, where vapour pockets always develop and may then result in choking the pump. Self-priming pumps could not be used for these applications.

Two new designs from Switzerland and Germany are claimed to deal with this aspect. They are the *Egger* pump and the *Eta-Jet* pump. Both use a contraction in the impeller, after which the shrouds widen out. This results in only partially filled impellers after a region of pronounced pressure reduction, thus providing space for vapour to be released and be pumped away. The *Egger* pump has the contraction at the blade inlet, whereas in the *Eta-Jet* the narrowest width of the impeller is at about half the impeller radius. These designs must be considered a distinct hydrodynamic advance and more will probably be heard of them in future.

Solids. All the pumps mentioned above will also deal with solids, provided the passages are large enough. In fact, the capacity of centrifugal pumps to deal with solids is quite astounding, provided the solids are small enough by themselves not to block the passages. Slurries, such as cement slurries, are successfully pumped with only 34% of water, or 66% solids content. Of course, the question of abrasion and corrosion remains. Manganese steel or solid rubber can deal with abrasion, but when corrosion also occurs both these

(*Concluded on page* 136)



Section through impeller of 'Eta-Jet' pump.

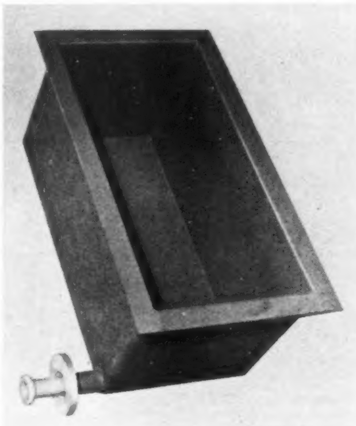
Plastics for Chemical Plant

By J. H. Collins, B.Sc., F.R.I.C.

This article outlines the progress that has been made in the application of some of the more important plastics to the construction of chemical plant and to other chemical industry uses. It discusses some of the newer materials and their uses and concludes with a comment on probable future trends.

TWENTY years ago the use of plastics materials in chemical plant was confined to the limited application of small quantities of acid-resistant phenol formaldehyde laminates. The main types of corrosion-resistant vessels were those lined either with natural rubber, glass or enamel and, to a growing extent, stainless steel. In 1939, polythene and polyvinyl chloride were both known and ready for commercial development, but neither had established itself and, indeed, it was not until after the war that supplies of polythene were adequate to permit its use for applications other than electronic. Synthetic rubbers from styrene and butadiene did not become important until 1942 and it was only in the later war years that 'no'- or 'low'-pressure thermosetting resins based on allyl alcohol appeared in the U.S.A. The polyesters as we know them today are post-war inventions, as also are the epoxy and the fluorocarbon resins.

In the last five years the use of polymeric materials in the construction of plant for the manufacture and for the handling of chemical products has increased several times over. This is due not only to an increase in the extent of known applications but also to the almost daily introduction of new uses for the various polymers. It has become impossible to give a comprehensive review of these materials in a single article and for this review a few of the more important polymers have been chosen. From an examination of the types of application each is finding, the likely pattern of future trends may be deduced.



'Vybak' rigid PVC is the main material for this chemical tank, while external reinforcement with glass-fibre mat and Bakelite polyester resin gives additional impact strength and rigidity. The tank was constructed by Cawley Plastics Ltd. A feature of this type of construction is that inlet and outlet pipes of unplasticised PVC may be an integral part of the structure and can easily be reinforced at the correct points.

Polyvinyl chloride

In tonnage, PVC is the most important polymer used in chemical plant construction. It is resistant to a very wide range of liquids and gases and it is cheap. The most serious limitation is that it is thermoplastic and softens at a temperature well below those at which many chemical reactions are carried out. This low heat resistance has some advantage economically as it means that the polymer can be converted from resin to pipe or sheet by simple and cheap methods. At a price of around 6s./lb. in a fabricated form, rigid unplasticised PVC materials compare favourably with any other material resistant to both acids and alkalis, providing working temperatures up to 60°C. are not exceeded. Any short table of properties is necessarily approximate and the wide variations in properties such as tensile and impact strength which are often quoted are mainly due to the varying methods by which the polymer is converted to the useful plastic form.

In Britain, there are two main sources of PVC polymers and several firms convert the polymer into rigid unplasticised sheet from which acid-resisting vessels and ducting are fabricated by welding. For many applications these products are self-supporting, but in some cases the sheet is used as a lining for metal vessels or

supported by a steel framework which is protected from corrosion by strips of PVC welded to enclose the metal in the structure.

Extruded unplasticised PVC has a high impact strength when compared with other thermoplastics, but a recent development has placed one particular grade far in advance of anything previously made. This is *Geon* RA 170, which has the following mechanical characteristics:

Table 1. Properties of 'Geon' RA 170

Temperature, °C.	*Izod impact strength (ft./lb./in. notch)*	*Safe working pressure for 3-in. pipe (p.s.i.)*
−40	1.0	—
+25	18.0	100—200
+60	16.0	40—80
+80	19.0	—

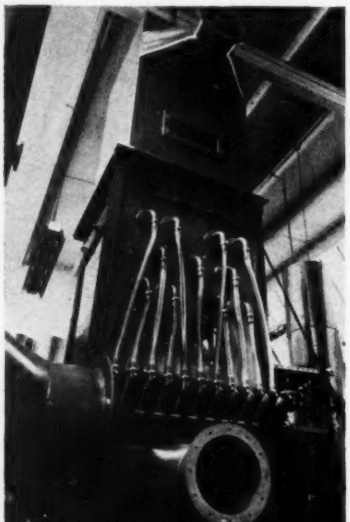
Moulded fittings can be made so that complete systems of, say, effluent disposal arrangements can be made in the same material. Some of these have now been in operation without the need for any maintenance for more than a year in circumstances where metal pipework would have required heavy repair work after only a few months' service.

Plasticised PVC is used in a number of applications where flexibility is required, but apart from temperature limitations the system of plasticisers used also calls for careful selection. Against aqueous media the flexible grades of PVC are generally satisfactory, but with organic solvents plasticiser leaching can be a serious difficulty, especially if exposure is intermittent. With tritolyl phosphate, for example, some interchange of plasticiser and petroleum-type solvents can take place. This in many cases does no harm unless the system falls temporarily into disuse, when the solvents in the PVC evaporate leaving a lower percentage of plasticiser in the plastic material so that, after a very few alternations of this kind, it becomes useless.

The major uses of plasticised PVC in the chemical industry are as protective clothing and this ranges from gloves and aprons for use in the corrosive conditions which exist in pickling and plating plant to the complete 'diving' suits used in laboratories and workshops handling radioactive materials. Recent investigations have been made on the most suitable plasticiser formulations for this latter purpose and it has been found that tritolyl phosphate (TTP) and the xylenol derivative (TXP) are the most satisfactory.

PVC flexible tapes have been developed as wrappings for pipes, joints and metal parts to protect them from chemical attack. The type of application varies from the wrapping of underground gas pipes to the protective masking of metal parts which are required to be only partially plated with chromium or other electrolytically applied finish. The adhesives used in such tapes are obviously of fundamental importance and it is often difficult to make a satisfactory bond. Of particular importance, therefore, is a tape recently marketed by John Gosheron Ltd., which is specially formulated to give a sufficiently high gloss to enable a satisfactory bond without the use of any applied adhesive. In the U.S.A., polythene is preferred to PVC for some wrappings, but in Britain both are in daily use. A wide range of film-forming plastics are constantly under test in this kind of application and several such as the polyester materials are likely to become widely used.

Amongst notable recent applications of PVC in the chemical industry is the construction of a 50-ft. exhaust chimney for a contact sulphuric acid plant. This was fabricated from $\frac{3}{16}$-in. rigid PVC sheeting and the supporting structure utilises epoxy resin-coated steel rims to carry the weight of the individual sections on a PVC-covered tubular steel framework. Less spectacular but of great importance is the use of PVC in a new type of ball valve which contains no metal parts. The PVC ball floats in polytetrafluoroethylene seats and can operate continuously at temperatures up to 55°C.



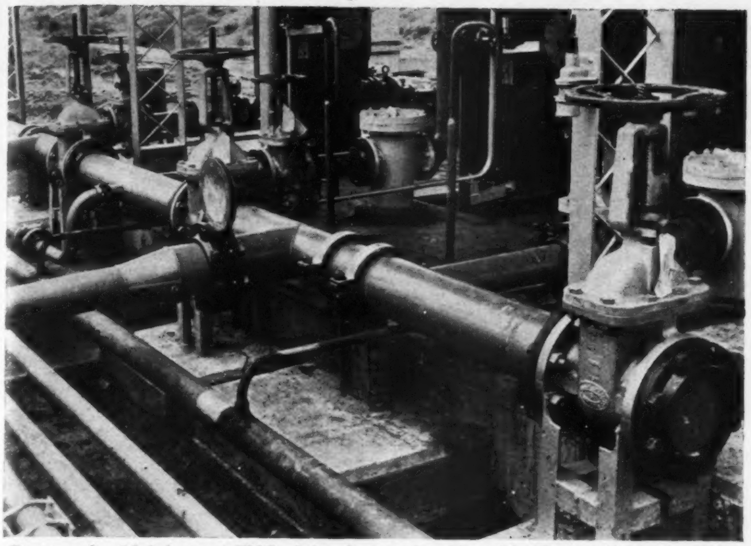
A large scrubbing tower fabricated from 'Vybak' industrial rigid sheet by Extrudex Ltd. The tower forms part of a fume extraction system used in metal refining and its purpose is to remove corrosive and noxious gases from the exhaust ducting. The transparent flexible pipes are extruded from 'Vybak' VN 610

Valves and fittings injection-moulded from Montecatini's 'Moplen' polypropylene show good resistance to strong acids and alkalis, solvents and grease. Tough and rigid, they can be used at high temperatures.

Polythene

There is a considerable overlap in the potential uses in the chemical industry of polythene and PVC particularly in the use of sheet and pipe. Both can be extruded into pipe and structures or linings can be fabricated from sheet materials by hot gas welding. Both can be made into film or thin sheeting or moulded into components of complex shape. It is interesting, therefore, to compare the fundamental characteristics of the two materials and for this purpose two grades of PVC, one rigid and unplasticised and the other a common flexible sheet grade, have been chosen for comparison. Polythene is now available in two main commercial forms, namely the old high-pressure polymer and the other the very recent but outstandingly important low-pressure polymer. To complete the comparison, Table 2 also includes the properties of the latest hydrocarbon polymer, polypropylene, which, although not yet available in large quantities, will become so in the very near future.

From the table it will readily be appreciated that rigid PVC is preferred for most chemical plant construction work since the mechanical properties are superior and resistance



One use for high-impact PVC piping is seen in this acid effluent disposal system at the British Petroleum Co. Ltd. refinery on the Isle of Grain. This particular installation used 11,000 ft. of 'Hipact' piping made by Extrudex Ltd. from material supplied by British Geon Ltd.

to acids and alkalis is practically complete. On the other hand, polythene is an easier material to extrude into pipe and, further, it can be fabricated by spinning methods into large-diameter pipe or pipe linings. Thus, for effluent disposal systems polythene has become popular. Recent developments are, however, changing the picture and the improved mechanical and heat resistance of the low-pressure polythenes and polypropylenes is likely to bring a greatly extended use of these polymers in large vats and fabricated plant. The new *Geon* RA 170 will bring a corresponding increase in the use of PVC for pipe work.

Both PVC and polythene are widely used in the ancillary aspects of the chemical industry, particularly for packaging. Polythene is rapidly replacing glass for containers of sizes up to and including the conventional carboy. This is due to the comparative ease with which it can be moulded. The techniques of blow moulding, originally designed for very small bottles for cosmetics, has now been extended into the packaging of a wide range of chemicals. Tanks as large as 50 gal. are not uncommon and recently one has been reported of 500-gal. capacity. The range of polythene goods for laboratory equipment has also increased tremendously in the last few years.

For drum liners polythene film or thin sheeting has not become as widely used as might be supposed and, very broadly, it can be stated that, whereas very thin (2 to 4 mils) polythene has found its way into the paper sack trade, plasticised PVC (10 to 20 mils) has claimed the market for liquid-containing drum liners.

Thermosetting resins and laminates

Before 1945, plastic laminates were almost exclusively a combination of natural fibre and conventional hot-curing synthetic resin, mostly cellulose or asbestos with phenol formaldehyde resin. They were used to some extent in chemical plant, but costs were high due to the slow machining methods which were necessary to fabricate from sheet and rod. Efforts to make moulded shapes had not achieved outstanding success. The advantages of these laminates over thermoplastic materials is that their mechanical strength is high enough to permit them to be used as load-bearing structures and they can be used at temperatures above 100°C.

The possibilities of the low-pressure laminates based on glass fibre and the polyester resins seemed tremendous

Table 2. Properties of PVC, Polythene and Polypropylene*

Property	*A.S.T.M. test*	*Polyvinyl chloride*		*Polythene*		*Polypropylene*
		Rigid	*Flexible*	*High-pressure*	*Low-pressure*	
Specific gravity	—	1.35	1.3	0.91	0.95	0.90
Heat distortion temp., °F. ..	D648	150	—	110	160 (66 p.s.i.)	220 (66 p.s.i.)
Tensile strength, p.s.i. ..	D638	7,000	2,500	1,500	4,000	5,000
Elongation at break, % ..	D638	300	300	400	100	400
Impact strength (Izod ½ in. × ½ in. notched ft./lb./in. notch)	D256	2—20	—	16	6	1.5
Hardness, Rockwell	D785	—	—	D41—D46	D68-D70 (Shore)	R85—95
Thermal expansion, 10^{-5}/°C.	D696	5—18	7—25	16—18	11—13	11
Burning rate	D635	Self-ext.	Slow to self-ext.	Slow	Slow	Slow
Effect of sunlight	—	Resistant	Resistant	Surface crazing unless black	Serious surface crazing unless black	Serious surface crazing unless black
Effect of weak acids	D543	Resistant	Resistant	Resistant	Resistant	Very resistant
Effect of strong acids.. ..	D543	Resistant	Very slight	Attacked by HNO_3	Slowly attacked by HNO_3	Slowly attacked by HNO_3
Effect of weak alkalis.. ..	D543	Resistant	Resistant	Resistant	Resistant	Very resistant
Effect of strong alkalis ..	D543	Resistant	Resistant	Resistant	Very resistant	Very resistant
Effect of ketones, esters ..	—	Swells	Swells	Resistant	Resistant	Resistant
Effect of hydrocarbons and chlorinated hydrocarbons ..	—	Resists aliphatic Swells aromatic	Swells	Swells in aromatics	Swells in hot aromatics	Swells in hot aromatics

*Inevitably these figures do not coincide exactly with those in the chart opposite page 134, all such data being approximate—Ed.

but resulted in many disappointments in the early stages of their development. As materials for complex fume hoods and ductings they seemed ideal, but the chemical resistance of the resins was not so good as was at first thought and the difficulties of excluding all air from a hand-made 'no'- or 'low'-pressure laminate were very great. For chemical plant work polyester resins are now used with glass-fibre reinforcements for a growing range of tanks and covers, but the newer family of these low-pressure resins, the epoxide resins, based on epichlorhydrin, is much superior both for laminates and surface coatings.

It is in the surface coating field that the epoxide resins have really established themselves in the chemical industry. It may have been fortunate that one of the largest producers of epoxide resins is also one of the largest oil and chemical companies. At any rate, extensive field trials were possible within their own organisation and, as a result, epoxide resin paints have become, perhaps, the most widely used corrosion preventatives on buildings, pipework, plant and containers used in the oil and chemical industries. It is not possible to elaborate here on the variety of uses which have been developed, but it may be permissible to digress for a moment into psychology. It was the writer's responsibility to organise the painting of one of the first 3,000-gal. oil-carrying road tankers to be coated on the inside with an epoxy resin paint. Previously these tanks had been coated with red oxide paint. Rather deliberately, a white pigmented formulation was used, the justification of which came when the finished work was inspected by an official of the oil company. As he looked through the manhole at the gleaming white walls his excited comment was, 'You can see inside here.'

Earlier mention was made of a chimney stack built from rigid PVC sheet. An acid-resistant fume stack has recently been built in Yorkshire using the Bakelite Co.'s polyester resins reinforced with glass fibre. The stack is built in 14 sections and stands 112 ft. high.

Fluorine resins

The unique properties of the fluorine-containing polymers have assured them of continuing interest in many fields regardless of the high price and the difficulty in manipulating polymers so resistant to solvents, chemicals and heat. Much of the novelty of the friction properties has passed and PTFE coatings on plant which is otherwise difficult to clean are now fairly commonplace. Recent developments in valve manufacture are notable and in a recently advertised application the I.C.I. material, *Fluon*, is used in contact with high-pressure superheated steam.

Several firms make a range of joint rings and gaskets and in various mechanical applications PTFE is bonded to asbestos or glass fabric. The most serious limitation remains the moulding process and PTFE can only be formed into complex shapes either by sintering the powder preform with all the difficulties of dimensional control or machined from the solid which is wasteful both of time and material. A compromise between corrosion and temperature resistance on the one hand and mouldability on the other is to be found in polytrifluorochloroethylene (PTFCE), but it is significant that no British firm has yet decided that the market here justifies the cost of production. It may be that the new American copolymer of hexafluoropropylene and tetrafluoroethylene designated *Teflon* 100X will supersede PTFCE. It is claimed to have most of the properties of PTFE, but in addition it can be melt-extruded into the conventional types of thermoplastic products. Even at the present price of £2/lb. a straight PTFE polymer finds a large potential outlet in the chemical industry. For extruded pipe, sheet and film materials with the properties of PTFE, the market must be considerably greater, so that if the new copolymer can be introduced around this price level it must find a ready demand.

Conclusions

The plastics industry has for a generation divided its products into two main types, the thermosetting and the thermoplastic. As the chemistry of polymer formation becomes more fully understood, there are signs that the old distinctions will become less pronounced, although the two classes of plastics material are likely to remain for many years. The two most important chemical developments in synthetic resins of the present decade are, in the author's view, the appreciation of the polyfunctionality of the combinations based on epichlorhydrin and the polyamines and the rapidly extending knowledge of the polymerisation of the lower olefines. One is producing a series of stable thermosetting products with exceptional chemical resistance based on a high degree of cross-linking, whilst the other, relying on the natural chemical inertness of a hydrocarbon chain, is producing a range of thermoplastics with softening points well above the boiling point of water.

The potential and the demand in the chemical industry for corrosion-resistant materials must mean still further and rapid expansion in the use of both of these types of polymers.

At the end of the last war, the German chemical industry was using 1,200 tons p.a. of rigid PVC pipe. In this country, development only really started in the present decade, but already it is well established for the construction of effluent pipe in oil refineries. A big drive is being made by two major plastics-producing companies to capture the water distribution pipe business and this effort is now achieving considerable success and the recent developments of higher strength and better temperature-resistant polymers must set the seal on the ultimate success of this move. The metal pipe market in Britain for 1957 has been estimated at more than 2 million tons. If as conservative an estimate as 5% of this changes over to plastic, it represents, allowing for specific gravity, an addition of 2,000 tons to the plastic pipe market. When considering chemical plant, pipework is probably the easiest starting point from which to introduce changes, but inevitably first the pipe fittings and then the specially fabricated vessels and containers follow.

Metal must, however, remain the dominant constructional material for a very long time yet and, therefore, corrosion-resistant coatings will provide an even greater part of the market for plastics materials than they have done in the past.

The making of estimates of future consumption of materials in tons p.a. is a popular occupation for which, fortunately, the errors of judgment are seldom penalised. Without quoting figures, therefore, this review is concluded with the comment that the increase in the use of plastics materials in the chemical industry in the next five years will, on any count, be very substantial.

To Authors

The Editor welcomes practical articles and notes on chemical engineering and related subjects with a view to publication. A preliminary synopsis outlining the subject should be sent to The Editor, CHEMICAL & PROCESS ENGINEERING, Leonard Hill House, Eden Street, London, N.W.1.

Graphite as a Material of Construction for Heat Exchangers

By A. Hilliard
(*Technical Adviser, Société Le Carbone-Lorraine*)

This article discusses the special considerations involved in using graphite as a material of construction, and takes, as an example of how its unique properties can be used to their full advantage, a heat exchanger formed from solid blocks of graphite. It is concluded that the same basic approach can be applied to other materials and to other types of equipment.

GRAPHITE is unique in its combination of a variety of remarkable properties, *e.g.* excellent thermal conductivity, highly versatile chemical inertness, good compressive strength, rigidity at elevated temperatures, self-lubrication, good electrical conductivity, etc., and it is particularly advantageous for the construction of heat exchangers and other chemical engineering equipment.[1]

The mechanical and physical properties of graphite differ in many respects from those of the commonly used metals, and different design considerations are therefore applicable. To employ graphite (or any other 'new' material) to best advantage, it is necessary to base the design on the properties of the material alone, ignoring previous practice with other materials.

Particular attention must be given to the fact that, unlike most metals, graphite is highly anisotropic and its compressive strength is much better than its tensile or flexural strength. Whereas the compressive strength of a good constructional graphite would be of the order of 15,000 p.s.i., its tensile strength is only a fraction of that figure. Furthermore, graphite is neither malleable nor ductile. To exploit the good compressive strength of graphite it is necessary to use it in the form of strong blocks.

Design considerations

The first graphite heat exchangers were based on the tube bundle system similar to corresponding metal units. This form does not exploit the good compressive strength of graphite, and the long thin tubes are exposed to tensile and flexural stresses. Cemented joints are required to fix the tubes into the header plates, and floating headers have to be used to compensate for differential expansion between the graphite tube bundles and the metal shell. The limiting working pressure of tubular units is usually only a fraction of that permissible for graphite block type heat exchangers. Any preferred orientation of the anisotropic graphite crystals is, in graphite tubes, opposite to the direction of desired heat transfer. In drilled blocks, the two sets of heat-exchange passages can be positioned to exploit anisotropic orientation for best thermal conductivity between the heat-exchange fluids.[1]

Heat exchangers which are based on a monoblock system, *e.g.* as disclosed by Stancliffe[2, 3] and others,[4] take advantage of the good compressive strength of the material. Stancliffe developed this system primarily for use with metals. Because it is difficult to drill long passages through a solid block, he suggested the formation of the heat-exchange passages either by the lost core method during casting[2] or, alternatively, by employing metal plates, grooved on both sides, and sweating together piles of such plates to form blocks.[3]

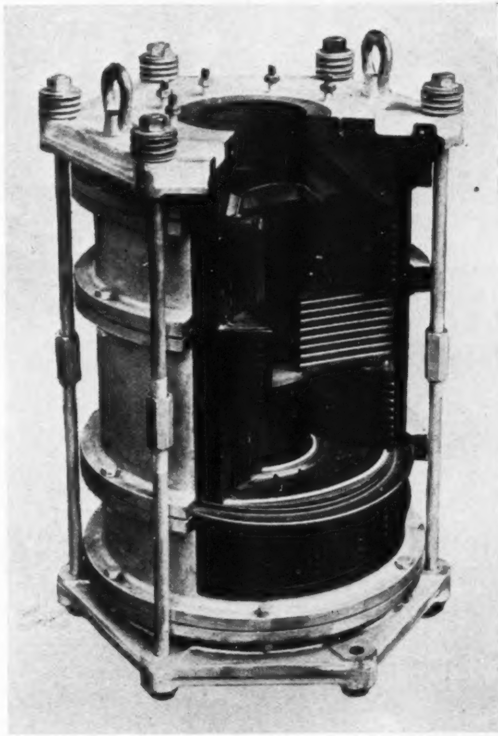


Fig. 1. Cut-away view of 'Polybloc' heat exchanger.

Fabrication

Graphite cannot be cast, or assembled by welding or sweating. Application of the Stancliffe system to graphite constructions involves, therefore, either the drilling of long passages through solid block, which is difficult and has other limitations, or the use of grooved plates which are cemented together to form heat-exchange blocks.

Cements which are suitable for use with graphite are substantially limited to resin-based materials. They may introduce problems of differential expansion, embrittlement of the cemented joints through the combined effect of temperature and certain heat-exchange fluids, and reduce versatility. Equipment which is rigidly cemented together is less versatile than detachably assembled units.[5]

These are some of the reasons why it is preferable not to apply the design principles of metal equipment to graphite constructions. The advantages of basing the design of graphite equipment on the characteristics of the material alone, without reference to prior art, will now be exemplified by the description of a heat exchanger, the *Polybloc*.[6–10]

'Polybloc' heat exchanger

This unit consists of a pile of cylindrical, homogeneous, graphite blocks. Each component block has a central hole and two sets of heat-exchange passages. One set (axial passages) is parallel to the axis of the block, and the second set (radial passages), which is interspaced between the axial passages, connects the central hole with the outer periphery of the block. The central hole is important, because it permits the accommodation of much larger heat-exchange areas in a block, without cemented joints, than would be practicable otherwise. Elastic gaskets between the blocks prevent contact of the two heat-exchange fluids. Headers are provided at the extremities of the column, and the assembly is held together detachably, under compression only, by external spring-loaded tie bars.

The process fluid passes through the axial passage system and contacts only impermeable graphite. The service fluid circulates through the radial passages. If heat exchange between two corrosive fluids is required, the metal shell can be protected by a suitable lining. Central obstruction discs and peripheral obstruction rings can be provided to obtain multipass flow.

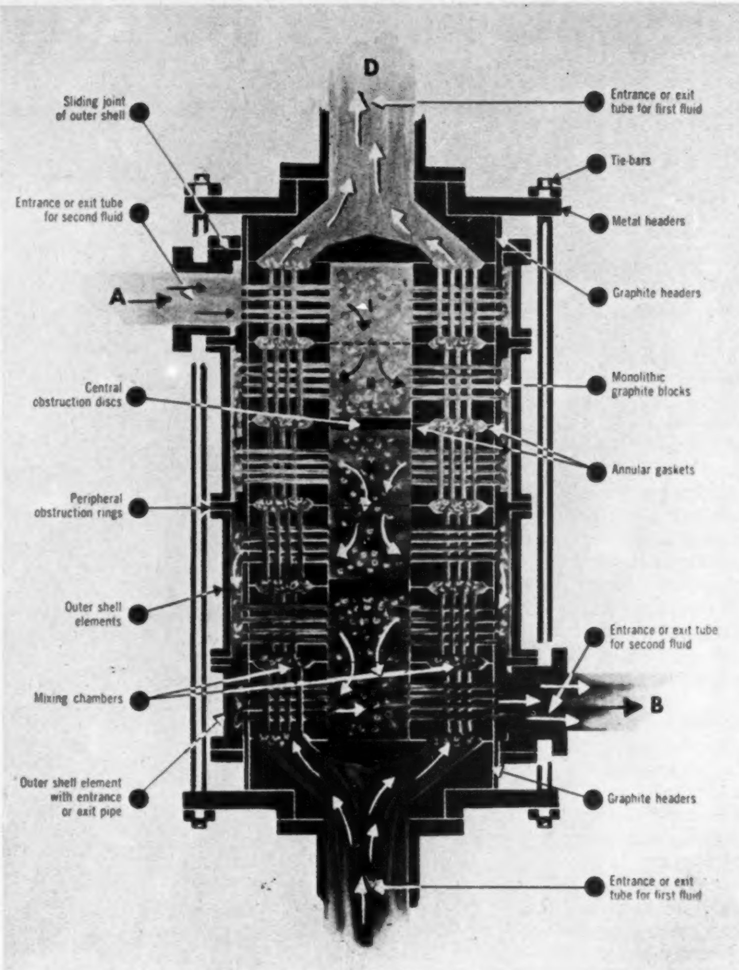


Fig. 2. Diagram showing construction of 'Polybloc' system.

Fig. 1 illustrates an assembled unit with part of the shell and blocks cut away to indicate the passage arrangement. Robustness is ensured by the shape of the blocks and by the avoidance of flexural and tensile stresses. The unit is assembled under compression only, and full advantage is taken of the good compressive strength of the material.

The whole assembly is completely protected against impact by the strong steel shell and header plates. The robustness of the unit is therefore comparable with that of metal equipment, and it is perfectly suitable for use in the heavy industries, *e.g.* steel pickling, etc. Fig. 2 shows the system diagrammatically.

Special features of 'Polybloc' assembly

All heat-exchange passages in the block are so arranged that any anisotropic orientation of graphite crystals is exploited for highest thermal conductivity between the two sets of heat-exchange passages. There are no cemented joints anywhere in the assembly. Fluid tightness is ensured by the provision of fully interchangeable gaskets between blocks. The cylindrical form of the blocks permits the use of circular gaskets, these being much more effective in ensuring fluid tightness than any other shape. Because of the ease with which fluid tightness is so obtained, there is a wide choice of available gasket materials. Polytetrafluoroethylene (*Fluon* or *Teflon*) has been found particularly advantageous, because it compares in its chemical inertness with graphite.

To permit the use of homogeneous graphite blocks free from cemented joints, all heat-exchange passages are made by drilling. They are therefore very short with respect to their diameter.

Because of the small length/diameter ratio of the passages, the 'end effect' is important in inhibiting streamline flow even at slow fluid flow rates. This improves heat-exchange efficiency.

Fig. 3 shows the steam/water heat-exchange coefficients of a PM model at varying water speeds from 0.05 to 2 m./sec. In this model one set of passages has a length/diameter ratio of 10 : 1 and in the second set of passages the ratio is 6 : 1. The turbulence effect of the small length/diameter passage ratio inhibits also the formation of scale and fouling.[11]

Application to absorption processes

Graphite heat exchangers are used extensively in absorption processes,

particularly for the manufacture of hydrochloric acid. Graphite is fully inert to any HCl concentration and its excellent thermal conductivity facilitates the cooling of the system, which is necessary for efficient performance. It is important for the absorbing fluid to be in the form of a continuous film, and also to induce turbulent flow of the gas to be adsorbed. A forthcoming paper,[12] which will describe a graphite unit which meets these requirements, explains that, if passages of trumpet shape are substituted for the axial holes in a unit as shown in Fig. 1, the absorbing fluid film is regenerated about every 2 in.[13, 14] The trumpet-shaped passages also introduce a venturi effect with respect to gas flow, inducing continuously regenerated turbulence of the gas (or vapour) which is to be absorbed.

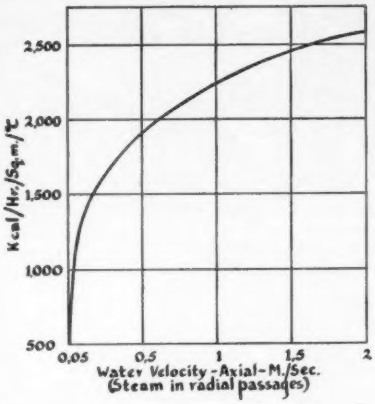


Fig. 3. Heat exchange coefficients steam/water for 'Polybloc' PM.

Conclusions

It will be seen that the design of the units described in the examples differs considerably from that of more conventional equipment. Because the construction is based on the characteristics of graphite, it has been possible to produce units which compare in their robustness with metal equipment, and at the same time comprise all the unique advantages of graphite. This indicates that it was right to design the apparatus around the properties of graphite only, without reference to prior art. It can be concluded that such considerations apply equally when using graphite for constructions other than heat exchangers, and that they are also generally applicable to the employment of any 'new' material.

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[8]Brit. Pat. 736,305.
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[11]B. A. Garman, A. Hilliard and N. H. Riches, 'Savings With New Type Heat Exchanger in Steel Pickling Plant' (in the press).
[12]A. Hilliard, 'Considerations on the Design of Corrosion-Resistant Absorbers' (in process of preparation).
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[14]Brit. Pat. 808,728.

Spacing of Bearings in Agitator Drives

To The Editor:

Dear Sir,

I have read with interest the description of the agitator drive unit you highlight on page 44 of your February issue. You say that the bearing spacing on this unit is approximately twice normal spacing and that this increases the stability of the complete unit. This is not so. An analysis of the fundamentals in beam design will show the opposite to be true. As the bearings or supports move further apart, the deflection of the shaft, due to a given overhung load, will of course be greater, not smaller.

Whereas extra-wide bearing spans in some cases result in decreased bearing loads, they very rarely are justified for agitator applications. They are not justified because, in most cases, the shaft diameter required to satisfy mechanical design requirements will determine the size of the bearings, and experience indicates that mixer drives selected for adequate power capacity at rated speed usually have ample radial bearing load capacity for normal agitator requirements. An increase in bearing span merely increases shaft deflection at the seal, which in turn reduces seal performance; also, this increase in the deflection of the shaft will lower the critical or whirling speed of the shaft system, relative to the operating speed.

You will readily appreciate from the foregoing that wide bearing spans increase shaft deflection and promote instability. These features we should try to eliminate, rather than draw attention to, as desirable. In my opinion, this is promoting unsound engineering practice.

Very truly yours,
I. MacLeod,
Technical Director.

Stockdale Engineering Ltd.,
U.K. Mixer Division,
Poynton, Cheshire.

The agitator drive to which Mr. MacLeod refers is manufactured by L. A. Mitchell Ltd. and Mr. F. Wynn, technical project engineer, fluid mixer division of that company, sends us the following comments:

We would state that 'the proof of the pudding is in the eating,' or the proof of the mix is in the mixing, and that the design in question has been tried in the field and has not been found to have any defects such as are implied by Mr. MacLeod's comment. Although there is no doubt that bearing loads are altered by wider spacing of the bearings, it should be remembered that the feature of the new design is increased stability as a whole, taking into account not only the section of the shaft between the bearings, but also the overhung length, the gearbox and the mounting.

We maintain that the extra length of shaft between bearings, assuming a fixed overhung length, when taken in conjunction with the method of coupling the shaft to the gearbox and motor, will tend to reduce the amount of vibration transmitted to the drive unit, due to out-of-balance loads imposed on the system during running conditions.

Longer-term D.S.I.R. grants

Longer-term grants for special researches will be awarded by the Department of Scientific and Industrial Research. These grants, which have normally been limited to a maximum of five years, may now be awarded for an initial period of up to seven years with the possibility of continuing support for a further ten years.

This change in policy has been made to meet the needs of more complex and expensive researches which may require support for more than five years to become fully established.

'Meehanite' in Chemical Plant

By E. G. Donaldson, B.Sc.
(International Meehanite Metal Co. Ltd.)

Although, in common with other low-alloyed or unalloyed ferrous materials, the Meehanite *metals are generally less corrosion-resisting than stainless steels, austenitic irons, nickel, copper, plastics, porcelain, etc., they have the advantages of good mechanical properties, low cost, ease of fabrication, and good resistance to abrasion, heat and thermal shock. They find a wide application in contact with chemicals which do not seriously attack them. This article considers some chemical plant uses.*

IN the general scheme of things cast iron resists corrosion better than steel and *Meehanite* metal offers greater corrosion resistance than ordinary cast iron. The main reason for the superiority of cast iron over steel is the presence of graphite and the relative absence of ferrite in the structure. These two constituents represent the extremes in corrosion resistance of those found in this group of materials. Intermediate are cementite and pearlite. Additional reasons are the casting skin, which often possesses greater resistance, and the fact that welds are a source of chemical weakness in fabricated structures.

Comparing *Meehanite* and grey iron castings, the former possess further advantages as follows:

(*a*) Absence of free ferrite.
(*b*) Finer structure of the pearlite.
(*c*) Improved shape and distribution of the graphite.
(*d*) Denser structure due to processing control related to the casting section.
(*e*) Precautions taken to produce castings that are perfectly sound and free from slag or other defects.

The last point is important because the worst enemies of chemical plant castings are cavities and inclusions of any type. Blow holes, porosity, shrinkage cavities, sand and slag inclusions act as centres of pitting and cut short the service life of castings.

Corrosion-resisting types of 'Meehanite'

The types of *Meehanite* specially processed for corrosion resistance are listed in Table 1 together with their main properties. Each of these types is strong, dense and machinable.

Type CB3 is special in that it is designed for use against sulphuric acid having a concentration greater than 77%. In this very corrosive medium, type CB3 has been found to give excellent service at temperatures up to 95°C. It is particularly recommended for pumps, valves, fittings, storage vessels, etc.

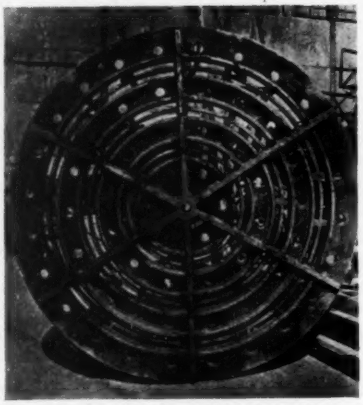

Fig. 1. Sulphuric acid washing-tower plate in 'Meehanite.'

Fig. 2. Pot for use in phenol manufacture.

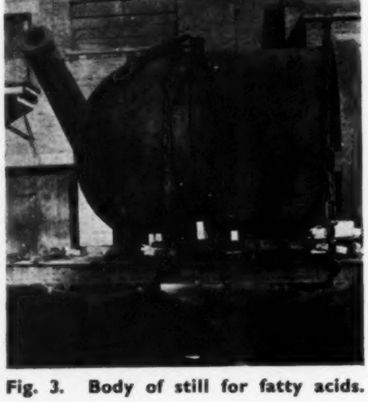

Fig. 3. Body of still for fatty acids.

A typical example of a washing-tower plate used in a sulphuric acid tower is shown in Fig. 1. These plates weigh 1 ton 6 cwt. each and were produced in type CB3 *Meehanite*.

Type CB has been developed specially to resist general attack to a greater extent than the general engineering types and at the same time to preserve good all-round mechanical and physical properties. It has found wide use in the form of pots, stills, pumps, valves, retorts, etc., for handling chemicals, mine water and sea-water and generally for solutions of less than 2 *p*H.

Type KC is used in certain cases of alkaline corrosion where the alkalinity is in excess of *p*H 6. Applications include pumps, valves, fittings, carbonators, causticisers, evaporators and pans.

Selection of material

The selection of the correct type of *Meehanite* for service under a particular set of conditions involving corrosion is vital. It is produced in four general groups: general engineering, heat-, abrasion- and corrosion-resisting types. The metal is processed according to the physical properties required. Thus the selection should be based on the structure of the material, rather than the chemical composition. This is essential because of the widely differing conditions in chemical plant.

In actual service it is often found that castings have to stand up to a combination of conditions. Heat combined with wear, or heat combined with corrosion, are often encountered and this calls for a type of *Meehanite* developed to suit the particular job. One example in which resistance to both heat and corrosion required is a retort, previously made in steel, for use in sulphur distillation. It weighs 7½ tons and is subjected to a continuous working temperature of 750°C. as well as to the corrosive effect of

Fig. 4. Sulphur distillation retort.

sulphurous gases. The type of *Meehanite* found most suitable was type HB, having a structure in which the free carbides were stabilised to prevent breakdown under the influence of heat, and at the same time resistant to corrosive attack.

The type of *Meehanite* and the structure of the metal thus depends on the conditions to be experienced in service. These factors and the preferred structure are indicated in Table 2.

In practically all applications the solution is more complex than that outlined in the table. The problem may result from a combination of several factors, say corrosion, high operating temperature and machinability required. This would involve a compromise and the advice of the foundry should be sought and acted upon. Often the foundry will also be able to suggest modifications to the design of the casting or the operating conditions which would simplify the problem and improve the casting performance.

An example of this occurred when pots for processing phenol were called for. The manufacturing process is carried out in two stages: (*a*) the sulphonation of benzene and (*b*) the reaction of benzene sulphonate with caustic soda to give sodium phenate and sodium sulphate. The latter operation was made the subject of the investigation. The conditions to which the pots are subjected are as follows.

This is a batch process, operating on three shifts; after emptying out the previous charge, solid caustic soda is added to the pot. Heating is continuous and during the emptying and charging period the temperature of the pot may reach 600°C. It is then rapidly cooled by the melting caustic soda, before being heated up to the desired temperature of 350°C., at which it is held during the addition of the sulphonate and until the completion of the reaction. Corrosive attack on the pots is slight. Some scaling occurs on the outside of the pot where it is exposed to the flame, but failure is invariably due to localised cracking long before any appreciable thinning has taken place. This is evidently caused by thermal shock or by local overheating caused by flame impingement.

The chemical firm has in the past used grey iron pots with indifferent results. The *Meehanite* foundry inspected the installation, advised on improved methods of firing and on the proper selection of the type of *Meehanite*. This resulted in the prolongation of the service life of these pots by three or four times. One of the pots is shown in Fig. 2.

Further examples of the successful use of *Meehanite* under various conditions are given in Table 3.

The use of type HE for intermittent heating is illustrated in a 7-ton boat pan which had four years of life when used for the production of ferric chloride. The still body shown in Fig. 3 was also made in type HE. It was used for the distillation of fatty acids and weighed 16 tons 6 cwt.

The use of a general engineering type of *Meehanite* is not ruled out particularly when excellent physical properties are required. Fig. 4 shows a sulphur distillation retort, weighing 1 ton 12 cwt., made in type GA. This replaced a 4% silicon cast-iron retort.

Special considerations

In conclusion it must be repeated that *Meehanite* is not a true corrosion-resisting material when compared with such materials as stainless steel, stoneware, plastics, etc. However, if the chemical environment is suitable it will prove satisfactory both practically and economically. The advent of new protective coatings, based on plastics and other materials, opens new horizons for *Meehanite* castings in the chemical industry. Lastly, the importance of collaboration between user and supplier cannot be over-emphasised.

Table 1. Corrosion-resistant 'Meehanite' metals

Type	*Service*	*Tensile strength (tons/sq.in.)*	*Brinell hardness No. (1.2 in. section)*	*Modulus of elasticity (million p.s.i.)*
CB3	Concentrated sulphuric acid	Up to 20.0	200 approx.	19
CC/CB	Acids and chemicals ..	Up to 20.0	>190	19
KC	Alkalis	Up to 15.0	200 approx.	14

Table 2. Guide to selection of 'Meehanite'

Service	*Preferred structure*	*Appropriate type of* Meehanite
Corrosion resistance	Pearlite matrix, minimum graphite	CC/CB, KC
High operating temperature	Pearlite/stabilised carbides	HB, HA, HR
Thermal shock	Ferrite/fine graphite	HE
Abrasion	Pearlite/cementite	WA, WB, WH
Machinability	Pearlite/graphite	GE, GC, GA
Mechanical properties	Pearlite/sorbite/minimum graphite	GM, GA, GC
Oxidation (scaling)	Ferrite/fine graphite	SC

Table 3. Typical applications of 'Meehanite' in chemical plant

Application	*Type of material used*
Fusion pots for caustic soda	HE for intermittent heating KC for continuous heating
Concentrators for alkalis, sulphides, ferrous salts	HE for intermittent heating CB or KC for continuous heating
Stills and pots for fatty acids	HE for intermittent heating CB for continuous heating
Valves, impellers, etc., for paper manufacture	KC for alkalis CB for acids
Retorts for sulphur production	HB
Salt cake pots	HE
Pumps handling alkalis	KC
Salt bath pots	HB
Pumps handling acids and chemicals	CB

Low-carbon Mn-Cr-Mo-V Steel for Pressure Vessels

By I. M. Mackenzie, B.Sc., A.I.M.
(*Colvilles Ltd.*)

As the size of welded pressure vessels increases, the use of mild-steel plates becomes less satisfactory and material of higher strength becomes essential. The only satisfactory solution is to introduce alloying elements while maintaining the carbon content at a relatively low level. The manganese-chromium-molybdenum-vanadium steel described in this article, was developed in the light of production experience to provide the desired combination of properties at the minimum cost.

In contrast to bars, forgings and castings, which are available in a wide variety of steels, the vast preponderance of plates are rolled in carbon-manganese steel, and for pressure vessels operating at temperatures below the creep range the use of carbon-manganese steel is almost universal. The slow progress made towards the application of alloy steels in this field is not due to any lack of enterprise on the part of designers, but is a consequence of the following three factors:

(*a*) The majority of alloy steels are used in the quenched and tempered condition, this treatment being necessary if full value is to be obtained from the alloy content. The shell end plates of pressure vessels usually have to be heated to a high temperature for forming and it has not proved practicable to carry out a subsequent quenching operation. Since the alloy steel must, therefore, be used in the air-cooled condition the full potential of the alloy contents is not realised.

(*b*) The plates forming pressure vessels are joined together either by riveting or welding. The former process proves impractical for thick plates of high-tensile steel and, despite the marked improvements in welding technique which have been brought about in recent years, the higher the tensile strength of the steel the greater the difficulty in welding.

(*c*) In the case of pressure vessels, the cost of the plates comprises a substantial part of the total cost. The increase in the tensile strength brought about by the introduction of alloying elements is accompanied by a more than proportional increase in the cost of the steel.

As the size of pressure vessels has progressively increased it has been found that, if mild-steel plates are used, the plate thicknesses become excessive, introducing such serious problems in handling, bending and welding the plates that the use of a higher-strength material becomes essential. It has been found that it is not satisfactory to bring about the necessary increase in the strength of the steel merely by increasing its carbon content. Not only does the higher average carbon content increase the welding problem but, when the steel is cast in the form of large ingots, severe segregation of carbon occurs producing undue variation in properties from one part of the plate to another. The only satisfactory solution to the problem is to introduce alloying elements while maintaining the carbon content at a relatively low level.

The low-carbon manganese-chromium-molybdenum-vanadium high-tensile weldable steel marketed under the name *Ducol* W30 has been developed to meet the demand for large high-tensile steel plates up to

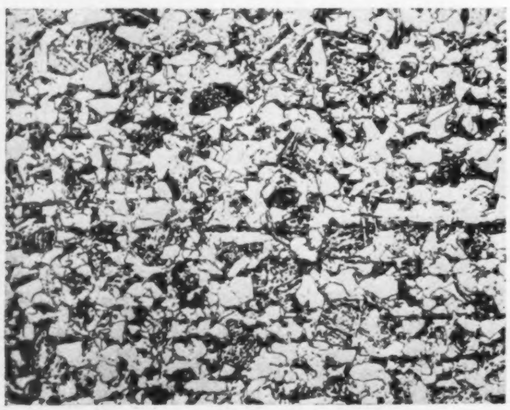

Fig. 1 (*left*). **Photomicrograph of 'Ducol' W30 steel in the normalised condition. Etched in Nital × 100.**

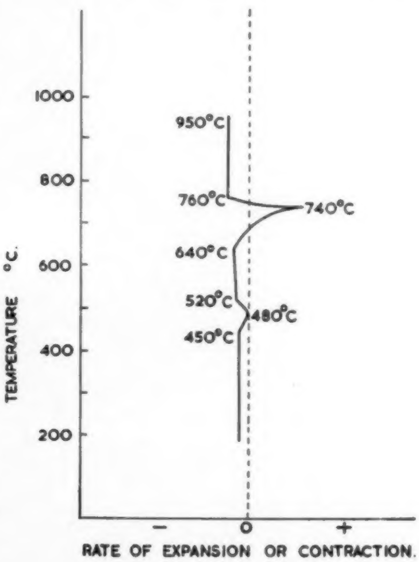

Fig. 2 (*right*). **Result of dilatometer test on 'Ducol' W30. Specimen cooled at the same rate as a 5-in. thick plate.**

6 in. thick. To make the steel as attractive as possible to designers, the factors mentioned above were given special consideration when the steel was under development. *Ducol* W30 belongs to a class of steel known as semi-air-hardening, and its properties are developed by air-cooling from the austenitic range followed by tempering and the same fabrication procedures can therefore be employed as for carbon steels. To ensure an adequate level of weldability the carbon content of the steel is restricted to 0.17% maximum and maximum limits imposed on the alloy content. The particular combination of alloying elements employed in the *Ducol* W30 steel was chosen in the light of production experience to provide the desired combination of properties at the minimum cost. In particular, certain elements which have been found to have an adverse influence on the casting and rolling characteristics of steel were avoided.

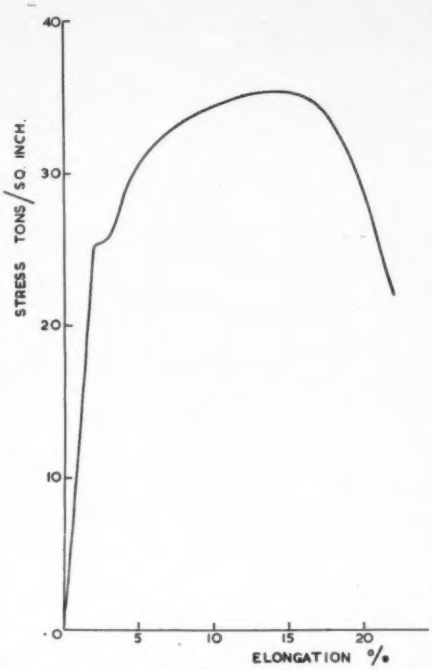

Fig. 3. Typical stress-strain diagram for tensile test on 5-in.-thick plate of 'Ducol' W30 steel.

In determining what properties should be guaranteed for the steel, it was obviously necessary to provide a substantial improvement over the available carbon manganese steels. For the range of plate thicknesses from 3 to 5 in. the properties obtainable in carbon-manganese steel are well represented by the A.S.T.M. A 212 Grade B specification which guarantees a minimum ultimate tensile strength of 31¼ tons/sq.in. and permits a carbon content up to 0.35%. The *Ducol* W30 steel was developed to have an ultimate tensile strength exceeding 34 tons/sq.in. for plates up to 6 in. thick and to have better weldability than the higher tensile carbon-manganese steels.

Composition and structure

The composition of a weldable semi-air-hardening steel is a compromise. With a higher carbon and alloy content a higher tensile strength will be obtained, but only at the expense of weldability. In the case of *Ducol* W30 steel the compromise target composition is as follows:

	%
Carbon	0.15
Manganese	1.3
Chromium	0.50
Molybdenum	0.26
Vanadium	0.08

The content of alloying elements is sufficient to delay the separation of pro-eutectoid ferrite and inhibit the formation of pearlite on air-cooling from the austenitic range. The structure of the steel in the normalised condition is shown in Fig. 1, and consists of a small amount of pro-eutectoid ferrite in a matrix of bainite. The progress of transformation as followed by dilatometric analysis is shown in Fig. 2. Tempering does not alter the structure as seen under the microscope but results in a uniform dispersion of tiny particles of alloy carbide throughout the bainitic ferrite without any appreciable decrease in strength. This structure, while inferior to that of higher-carbon alloy steels in the quenched and tempered condition, in which there may be complete absence of ferrite, does, nevertheless, provide a very satisfactory combination of strength and toughness.

If the *Ducol* W30 steel is rapidly cooled from the austenitic range, as occurs for example in the heat-affected zone of a weld, transformation is depressed to below the M.S. temperature. The hardness of the resultant transformation product depends primarily on the carbon content of the steel and it is to minimise this hardness that the carbon content is restricted.

In producing such a steel in large quantity by the basic open-hearth process some variation in composition from cast to cast is obviously inevitable. The upper limit of carbon and alloy contents is specified to safeguard the weldability of the steel. The maximum composition permitted by the specification is as follows:

	%
Carbon	0.17
Manganese	1.50
Chromium	0.70
Molybdenum	0.28
Vanadium	0.10
Nickel	0.30

No lower limit of composition is included in the specification since this is effectively controlled by the fact that, if there is an insufficient content of carbon and alloying elements in the steel, the minimum specified tensile properties will not be achieved.

Mechanical properties

In common with all other semi-air-hardening steels the properties of *Ducol* W30 steel are affected by the rate of cooling from the austenitic range. For the range of plate thicknesses from 3 to 6 in. the effect is not unduly great; however, a substantially higher strength can be guaranteed for thinner plates.

The magnitude of this effect is illustrated by the following figures which show the minimum tensile properties guaranteed for plates in different thickness ranges:

Thickness (inches)	*Yield stress (tons/sq. in.)*	*Ultimate tensile stress (tons/sq. in.)*
⅜ up to 1 ..	30	38
Over 1 up to 3..	27	36
Over 3 up to 6..	24	34

The majority of the *Ducol* W30 plates used for the manufacture of pressure vessels have been within the range 3 to 5 in. thick and the following remarks apply to plates within this thickness range.

The ultimate tensile strength of the steel in the normalised and tempered condition is guaranteed to be within the range 34 to 40 tons/sq.in., a typical stress-strain curve being shown in Fig. 3. The steel shows a definite yield point and the minimum guaranteed by the specification is 24 tons/sq.in. In the tensile test the steel behaves in a manner intermediate between that of ordinary mild steel and fully heat-treated alloy steel, in that, compared to mild steel, the reduction of area is increased and the general elongation somewhat reduced. The elongation on a gauge length of 8 in. will normally be well in excess of the figure of 13% which is the minimum guaranteed.

It will be noted that the ratio

$$\frac{\text{Yield stress}}{\text{Ultimate tensile strength}}$$

is substantially higher for the alloy

steel than for carbon-manganese steel. While the subject is still controversial there is a general swing of opinion towards the view that the ratio

$$\frac{\text{Design stress}}{\text{Yield stress}}$$

is of at least as much significance as the ratio

$$\frac{\text{Design stress}}{\text{Ultimate tensile strength}}$$

in determining the safe working pressure of a vessel. In other words it should be possible to upgrade the design stress for high-yield steels above that of carbon-manganese steel of the same ultimate tensile strength without any reduction in the effective safety factor. Such a development would immediately increase the benefits to be gained from the use of alloy steels.

One of the obstacles to be overcome before the superiority of the high-yield steel can be established is to resolve the problems of how far the inherent fatigue strength of the steel influences its behaviour in service, and how far the ultimate tensile strength is indicative of the resistance to fatigue. Present indications are that design is of overwhelmingly great importance in determining the liability to fatigue failure. It should be possible to clarify this important aspect of the design problem by testing vessels to destruction in the laboratory. However, there have been so few cases of vessels failing in service that the various authorities cannot agree as to which of the possible modes of failure are of practical significance, and until reasonable unanimity is reached on this point no systematic series of experiments is likely to be carried out. In the meantime the metallurgist can only judge the issue on the basis of Continental experience which highly stresses high-yield steels. This experience indicates that the design stresses can be increased substantially without any risk of fatigue failure.

Being intermediate in characteristics between mild steel and quenched and tempered steel, the semi-air-hardening steels have better notch ductility than the former. Vee-notch Charpy temperature/impact curves for a number of 5-in.-thick plates are shown in Fig. 4. This level of notch ductility is ample to ensure freedom from brittle fracture during fabrication during the hydraulic pressure test, and in service.

Weldability

In order to discuss the weldability of the steel it is necessary first to make reference to the circumstances in which trouble may be anticipated when fabricating a pressure vessel in this type of high-tensile material. Experience has indicated that little difficulty is to be anticipated in producing entirely satisfactory butt welds. Trouble is most likely to arise with fillet welds such as are employed for fixing attachments to the surfaces of the plates. The metal adjacent to such weld runs is heated to a high temperature and then cools rapidly so that it is hardened to a level which depends primarily on the carbon content of the steel. Under certain circumstances cracks may form within the hardened zones. The susceptibility of a steel to such heat-affected zone cracking may be assessed by carrying out the controlled thermal severity weldability test devised by the British Welding Research Association. In this test a series of fillet welds are laid under controlled conditions, the cooling rate of the weld deposit being varied by altering the geometry of the test set-up. The test welds are sectioned and examined under the microscope for evidence of cracking in the heat-affected zones. A most important result of such tests is to demonstrate the great influence of hydrogen derived from the electrode coating on the susceptibility to cracking. Table 1 shows the results of C.T.S. tests on *Ducol* W30 using different types of electrode. While there is serious cracking when rutile-coated electrodes are used there is no cracking with low potential hydrogen electrodes. It may well be said that it is the development of the low potential hydrogen basic-coated electrodes (B.S.S. 1719, Class 6) that has made the use of high-tensile low-alloy steels a practical proposition.

By means of the C.T.S. test it has also been possible to confirm the practical finding that, even with electrodes which liberate substantial concentrations of hydrogen during welding, heat-affected zone cracking may be avoided by preheating the parent

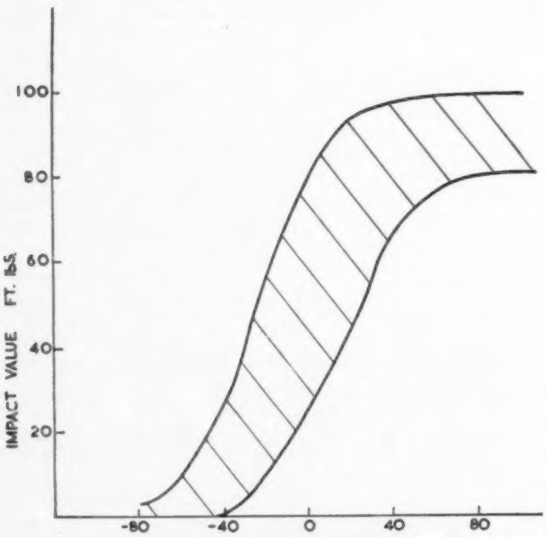

Fig. 4. Vee-notch Charpy temperature/impact curves for 5-in.-thick plates of 'Ducol' W30 steel.

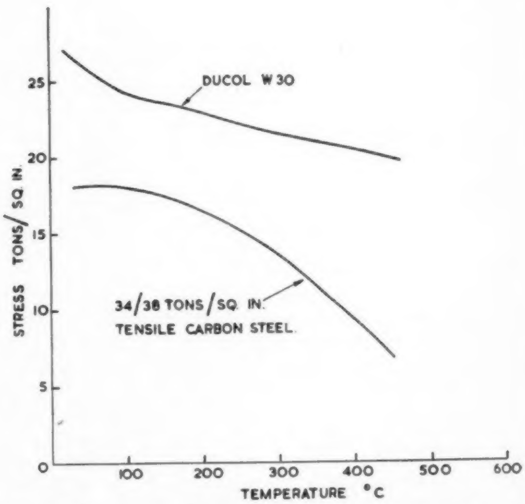

Fig. 5. Effect of testing temperature on the 0.2% proof stress of 'Ducol' W30 steel and of a carbon-manganese steel having the same ultimate tensile strength at atmospheric temperature.

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NON-METALS	METALS

	MATERIAL	CORROSION RESISTANCE	APPROX. ULTIMATE TENSILE STRENGTH (p.s.i.)
METALS	Aluminium (99.5% Al)	Suitable for handling nitric acid of greater concentration than 80%, many salts, organic chemicals, hydrogen sulphide and hydrogen peroxide. Not satisfactory for hydrochloric or sulphuric acids, salts of heavy metals and alkalis. The corrosion products are colourless and non-toxic.	10,000 to 13,400
	Aluminium bronze	Similar to copper, but has a greater resistance to oxidation at moderate temperatures.	56,000 to 112,000 wrought 67,200 to 100,000 cast
	Bronze and gunmetal	*See Copper*	44,800 to 145,600 wrought 35,800 to 49,200 cast
	Cast iron (grey)	Most useful under neutral or alkaline conditions, has good resistance to high concentrations of caustic alkali. Resistance to dilute acids is low, but it is often used where iron contamination of the product can be tolerated because of its low replacement cost. Suitable for sulphuric acid of over 80% concentration, but not suitable for oleum. More resistant to hot sulphuric acid than mild steel.	22,400 to 58,200
	Copper	High corrosion resistance except in oxidising environments, ammonia and mercury salts. Resistance to mineral acids depends on the degree of aeration.	31,300 to 33,600 annealed
	Corronel 210	Resists hydrochloric acid at all concentrations and temperatures. Up to 212°F. is resistant to all concentrations of sulphuric acid. The presence of oxidising ions increases the corrosion rate of these acids on the alloy. Is also resistant to phosphoric acid.	About 134,000 hot-rolled bar, annealed
	High-silicon iron	Good resistance to sulphuric and nitric acids at all concentrations and temperatures. Unsuitable for use with oleum, alkalis, hydrochloric or hydrofluoric acids.	22,400
	Inconel	Superior to nickel and *Monel* in resistance to oxidising acid salts, but not suitable for ferric, cupric or mercuric chlorides. At ambient temperatures, resists attack by nitric acid where the concentration is greater than 20%. Resistant to hot concentrated sodium sulphide and magnesium chloride.	90,000 hot-rolled bar, annealed
	Lead	Can be used for handling cold sulphuric acid up to 95%, hot sulphuric acid up to 80%, chromic, phosphoric and sulphurous acids. Not suitable for acids which form soluble lead salts or for strongly alkaline solutions.	2,200 Varies with rate of application of load
	Mild steel	Unsuitable for use with dilute acids but satisfactory for sulphuric of greater concentration than 80%, oleum, and for alkalis except concentrated caustic alkalis. Can be used for handling dry chlorine, fluorine and hydrogen fluoride. Rusts in moist air and must be protected by painting.	56,000 to 78,400
	Monel	Good resistance to many acids over wide range of conditions. Not resistant to mineral acids of an oxidising nature. Resists hydrofluoric acid. Can be used with sulphuric acid up to 80%—greater concentrations in certain circumstances. Resists alkalis, except hypochlorites. Not resistant to most oxidising acid salts.	About 85,000 hot-rolled bar, annealed
	Nickel	Very good resistance to caustic alkalis, ammonia, neutral and alkaline salt solutions, chlorinated solvents and phosphorus oxychloride. Not recommended for use with oxidising salts.	About 56,000 hot-rolled bar, annealed
	Stainless steel (austenitic) Cr 18%, Ni 8%, C 0.12% max., Ti 4 X C min.	Can be used in contact with all concentrations of nitric acid and many neutral salts. Not satisfactory for hydrochloric or sulphuric acids, chlorides, hot chromic acid and formic acid. Not recommended for use with acetic acid where the concentration exceeds 5%.	90,000 (softened)
	Tantalum	Excellent resistance to acids, except hydrofluoric. Resistant to dry and moist chlorine. Not suitable for use with caustic alkalis.	50,000 annealed 0.01 in. sheet
	Tin	Resistant to some aqueous acids and weak alkalis.	2,000
	Titanium	Resistant to attack by sea-water, acetic and chromic acids. Not suitable for use in contact with hydrochloric or sulphuric acids.	60,000
	Zirconium	Good resistance to acids, but not as good as tantalum. Not suitable for use with moist chlorine. Excellent resistance to attack by fused caustic alkalis.	59,000 annealed
NON-METALS	Chemical stoneware	Resistant to all acids except hydrofluoric and hot concentrated phosphoric. Not entirely resistant to alkalis but can be used if concentration and temperature are low.	1,000 to 2,400
	Ebonite	Natural and synthetic rubber ebonites withstand a wide range of chemicals, chief exceptions being mineral oils, certain solvents, and exceptionally strong oxidising agents. Ebonites made from nitrile rubbers are highly resistant to mineral oils and solvents.	Up to 10,000
	Glass (borosilicate)	Resistant to almost all chemicals except hydrofluoric acid, hot alkalis and hot concentrated phosphoric acid.	10,000
	Glass-fibre-reinforced plastics	Depends chiefly on the resin used. Epoxide resins have generally good chemical resistance, and furane resins have exceptional resistance to alkalis.	20,000 to 120,000
	Graphite (impervious)†	Resistant to all chemicals except substances which are highly oxidising such as halogens, chromic acid, hypochlorites and nitric acid of concentration greater than 20%.	2,500
	Neoprene	More resistant to oils, oxidising agents and weathering than natural rubber.	3,000 upwards
	Nylon‡	Resistant to many inorganic chemicals, but not suitable for use with mineral acids, hypochlorites, permanganates or hydrogen peroxide. Resistant to alkalis. Good resistance to organic solvents. Some exceptions are acetic and formic acids, phenol, cresol, and at elevated temperatures benzyl alcohol, nitrobenzene, ethyl acetate and butyl acetate.	5,000 to 40,000
	Polythene	Unattacked by most chemicals at room temperature and resistant to solutions of inorganic salts up to 212°F. At temperatures above 140°F. becomes increasingly soluble in aliphatic, aromatic and chlorinated hydrocarbon.	1,200 to 2,000
	Polythene (high-density)	Similar to polythene but more resistant to solvents and can be used at higher temperatures.	4,200
	PTFE (polytetrafluoroethylene)	Unaffected by all chemicals except molten alkali metals and fluorine at elevated temperatures and pressures. May be used up to 250°C. (482°F.).	2,000 upwards
	PVC (unplasticised)	Resistant to moist solutions of inorganic salts at temperatures up to 140°F., also 50% nitric acid, 90% sulphuric acid and hydrochloric acid. Some organic chemicals attack the material: examples are acetone, benzene, cyclohexanol methyl chloride, trichloroethylene.	7,000 to 8,000
	PVC (high-impact)	*See above.*	5,000 to 6,000
	Rubber (natural)	Withstands a large range of chemicals in general use. Chief exceptions: mineral oils, the majority of organic solvents, and very strong oxidising agents, but resistance to many of these can be provided by the use of special-purpose synthetics.	1,000 to 3,500

† Physical properties are for *Karbate*

‡ ,, ,, ,, ,, the moulding material

We acknowledge with thanks the co-operation of the following companies and organisations in supplying infor
impact PVC); The British Glass Industry Research Association (*borosilicate glass*); *British Hydrocarbon Che*
gunmetal, copper, aluminium bronze); *Crane Packing Ltd.* (*PTFE*); *Doulton Industrial Porcelains Ltd.* (*stonew*
Firth-Vickers Stainless Steels Ltd. (*stainless steel*); *Samuel Fox & Co. Ltd.* (*stainless steel*); *Imperial Chemica*
(*nickel*, Monel, Inconel, Corronel 210); *Murex Ltd.* (*tantalum, zirconium*); *Nylonic Engineering Co. Ltd.* (*ny*

& Process Engineering" Guide to Materials of Construct

APPROX. ULTIMATE TENSILE STRENGTH (p.s.i.)	APPROX. HARDNESS (Brinell)	IMPACT STRENGTH (Izod)	SPECIFIC GRAVITY	THERMAL CONDUCTIVITY (B.Th.U.)/(hr.) (sq.ft.) (°F./ft.)	COEFFICIENT OF LINEAR EXPANSION (per °F. × 10⁶)	SPECIAL REMARKS ON FABRICATING F
10,000 to 13,400	21		2.7	130	13	Careful design is necessary, as the metal is liable to 'crevice attack.' V the possibility of flux inclusions in crevices. *See Stainless Steel* fo
56,000 to 112,000 wrought 67,200 to 100,000 cast	80 to 280		7.8 (10% Al)	17 to 48	9.5	Alloys with up to 7% Al used in wrought condition. Castings and strength.
44,800 to 145,600 wrought 35,800 to 49,200 cast	60 to 250		8.8	17 to 60	10	Mainly used as castings. Lead is often added to improve machinabilit
22,400 to 58,200	160 to 230	6 to 35 unnotched bar	6.8 to 7.5	24 to 32	6.1	To eliminate possible sites for starting corrosion, castings should be de cores. Can be machined satisfactorily.
31,300 to 33,600 annealed	45 to 55		8.9	222	9.5	Easy to work. Can be joined by welding, brazing or soldering.
About 134,000 hot-rolled bar, annealed	About 250	70	9.2	6.5	5.5	Must be heat-treated after welding to prevent weld decay. (An allo require post-welding heat treatment.)
22,400	450 to 500	8 to 10 unnotched bar	6.9	19	6.8	Cannot be machined, and any shaping of the casting must be done b should be handled like stoneware. Fresh castings must be stress reli with cast iron.
90,000 hot-rolled bar, annealed		200	8.5	8.7	6.95	No unusual difficulties. Can be welded by usual techniques.
2,200 Varies with rate of application of load	5		11.3	20	16	Easy to work and weld. Has a low creep stress; careful considerati lead linings must be adequately supported. Alloyed with antimony corrosion resistance.
56,000 to 78,400	109 to 163	25 to 80	7.7 to 7.9	30	5.7 to 6.6	For chemical plant is usually joined by welding. Unless specially allo
About 85,000 hot-rolled bar, annealed		115 upwards	8.8	15	7.8	No unusual difficulties. Weldable by usual techniques.
About 56,000 hot-rolled bar, annealed		70 to 85	8.9	35	7.4	The metal work hardens. It can be joined by welding.
90,000 (softened)	180 (softened)	80 (softened)	7.9	9.2	8.9	Should be stored and handled under clean conditions. Electrodes inert gas welding frequently used in fabrication. The alloy work h
50,000 annealed 0.01 in. sheet	75 to 125		16.6	32	3.6	Joined by inert gas welding. Can be spun or machined. Because c very thin sections, *i.e.* sheets 0.012 to 0.015-in. thick.
2,000	5		7.3	37	12.8	Used as a coating on mild-steel plate or copper.
60,000	150 max.		4.5	9.6	5	Joined by inert gas welding with slight modification to the normal te
59,000 annealed			6.5	9.6	3	Joined by inert gas welding. In machining the swarf tends to be pyro
1,000 to 2,400			2.2 to 2.6	0.5 to 1.5	2.1 to 2.9	Size limitation 5 ft. to 8 ft. Iron armouring can be used to eliminat tensile strength.
Up to 10,000	10 to 24	1 to 7.5 about 32°F.	1.13 to 2.0 or more	0.08 to 0.16	40	Moulded, hand-built or machined by the usual techniques.
10,000			2.2	0.65	1.8	High temperatures are required for working glass.
20,000 to 120,000		20 to 70	1.5 to 1.9	0.1 to 0.25	5 to 18	Shaped by various moulding techniques and by casting. Carbide-tipp and abrasion discs are recommended for sawing.
2,500		0.32	1.9	85	2.4	Easily machined. Pipes may be joined by threading or by flanges.
3,000 upwards			1.2 to 1.5	0.11 to 0.12		*See Rubber (natural).*
5,000 to 40,000	8 to 12	0.6 to 4.7	1.04 to 1.15	0.14	60 to 100	Easily machined. Usually joined by threading or by special cements. in certain circumstances.
1,200 to 2,000	2	18 to 20	0.92	0.19	160	May be moulded by injection or compression. Joined by fusion or organic polar liquids, certain grades may be subject to stress crack
4,200	6	2 to 20	0.96		130	*See Polythene.*
2,000 upwards		4	2.1 to 2.2	0.14	55	Normally compression moulded, but fabricated by special extrusion t
7,000 to 8,000	12 to 15	2 to 5	1.41 to 1.45	0.1	45	Joined by special cement or hot gas welding. May be moulded at 23
5,000 to 6,000	10.6	15	1.3 to 1.4	0.1	50	Notch sensitivity less than for normal rigid PVC.
1,000 to 3,500			0.95 to 2.0 or more	About 0.08	120	In lining vessels, care must be taken that air is not trapped betwee vessel must be carefully prepared before lining.

n supplying information for this chart: British Acheson Electrodes Ltd. (impervious graphite); The British Cast Iron Research Association (cast iron); British Geon Ltd. (high-densi Hydrocarbon Chemicals Ltd. (polythene); The British Iron & Steel Research Association (mild steel); Brown Bayley Steels Ltd. (stainless steel); The Copper Development Assoc lains Ltd. (stoneware); Du Pont Co. (United Kingdom) Ltd. (neoprene); Federation of British Rubber and Allied Manufacturers (rubber, ebonite); Fibreglass Ltd. (glass-fibre-rei Imperial Chemical Industries Ltd. (titanium, unplasticised PVC, polythene, nylon); William Jessop & Sons Ltd. (titanium, stainless steel); Lead Development Association (lead); Mo ring Co. Ltd. (nylon).

truction

FABRICATING PROPERTIES	*MAIN APPLICATIONS IN CHEMICAL PLANT*
evice attack.' Welds must be carefully designed to avoid *Stainless Steel* for storage precautions.	All types of equipment. Since the corrosion products are non-toxic, can be used in processes which depend on the growth of micro-organisms, *e.g.* antibiotics.
Castings and forgings with added Fe and Ni have high	Condenser tubes, pump parts, valves.
ove machinability.	Pumps, valves, bearings.
gs should be designed as far as possible to avoid supported	Pipes, tanks, evaporator bodies, filter presses, valves, reaction vessels.
soldering.	Evaporator tubes, heat exchangers, distillation plant for alcohols and esters. Brewing plant, jam pans, solvent recovery plants and piping for many purposes.
decay. (An alloy, *Corronel 220*, is available which does not	Pump parts, reaction vessels, heat exchangers, valves.
must be done by grinding. Brittle, and during erection ust be stress relieved. Shrinking of casting is greater than	Pipes, tower sections, pumps, valves, tanks.
niques.	Bubble caps and bubble-cap trays, furnace components. Plant for photographic emulsions and photographic processing.
reful consideration must be given to this in design, and with antimony to increase hardness, but this lowers the	Pipes, valves, ducts, tanks, heat exchangers, linings for plant, tanks and pipes. Shieldings for atomic radiations.
ess specially alloyed becomes brittle at low temperatures.	Structural work, tanks, valves, heat exchangers, drums, ducting and pressure vessels.
.	All types of equipment.
g.	Reaction vessels for chlorination processes, plant for production of artificial rayon, tanks, and as a plating to give a corrosion-resistant coating.
ns. Electrodes for welding are stabilised with niobium; he alloy work hardens.	All types of equipment.
ned. Because of its corrosion resistance, can be used in k.	Linings for hydrochloric acid absorbers, heat exchangers, repair plugs for glass-lined tanks and spinnerets for the production of artificial rayon.
	As tinplate for containers in packaging. As a coating on copper stills for making distilled water.
to the normal technique.	Linings, heat exchangers, reflux towers, electrodes for electrochemical processes, valve components.
ends to be pyrophoric.	Not yet used to any extent in chemical industry. The hafnium-free metal has a low cross-section capture for neutrons and is of interest in nuclear engineering.
used to eliminate the possibility of damage and improve	Pipework, absorption towers, vessels, ball mills, grinding media, vacuum filters, cooling coils, pumps, fans, mixing and storage vessels, cocks.
ques.	Pipes, linings, valves, pumps, buckets.
	Pipelines, linings for tanks, heat exchangers, fractionating columns, inspection windows.
g. Carbide-tipped tools are recommended for machining	Fans, ducting, pipes drying traps.
r by flanges.	Heat exchangers, absorbers, globe valves, packed towers, pumps.
	See Rubber (natural).
pecial cements. Can be used up to 245°F. or up to 300°F.	Valve seats, piping, filter cloths, lubricant-free gears and bearings.
ed by fusion or hot gas welding. In contact with some t to stress cracking.	Pipes, vessels, tank linings, valves, containers.
	Piping for effluents and corrosive liquids, also tanks.
ecial extrusion techniques.	Tubing, gaskets, dispersion coatings, pump and valve packings, bellows.
e moulded at 230 to 265°F. or can be extruded.	Welded tanks, heat exchangers, pipes, valves, fittings, ducting, fume cabinets.
	Pipes, tubes and fittings.
trapped between the rubber and the vessel. Surface of	Tubing, tank linings, gaskets.

Ltd. (high-density polythene, high-
velopment Association (bronze and
. (glass-fibre-reinforced polyester);
ation (lead); Mond Nickel Co. Ltd.

IMPORTANT: This chart is intended only as a general guide to the chief materials of construction used for chemical plant. It is not possible, in the space available, to give comprehensive data for all the various grades of the materials listed; each material is therefore treated on its broad merits and only the order of properties to be expected is indicated. Where it has not proved possible to give typical physical properties, figures are given for one well-known grade of the material in question.

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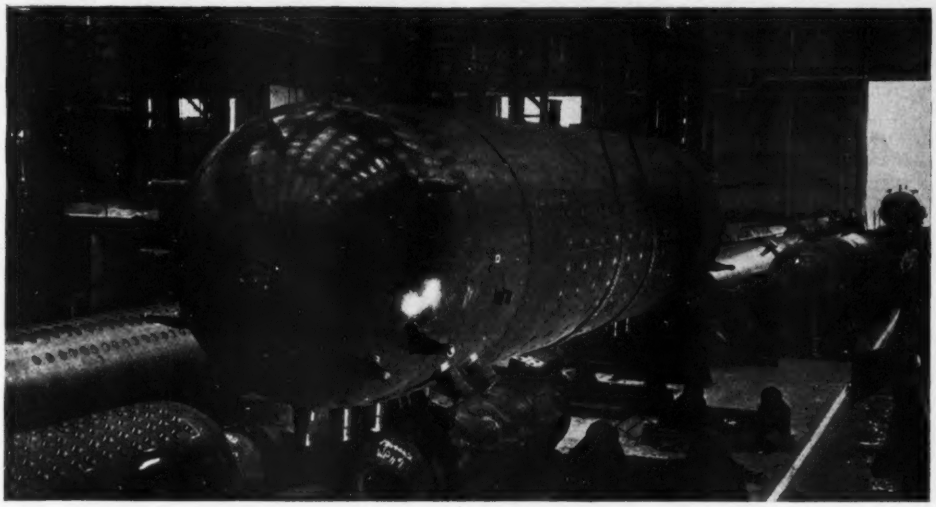

Fig. 6. Boiler drum fabricated by Babcock & Wilcox Ltd., using 'Ducol' W30 steel. Weight, including internal fittings, 43 tons.

metal between 100 and 200°C., and maintaining this temperature during welding. This effect is illustrated by the results in Table 2. To some extent a similar effect is obtained by using large-gauge electrodes and a high power input.

It is therefore recommended that for tack and fillet welding of *Ducol* W30 thoroughly dried basic-coated electrodes be employed with a moderate degree of preheat.

High-temperature properties

Many pressure vessels operate at temperatures substantially above atmospheric and current developments in the procedure for designing vessels are directing increasing interest to the effect of temperature on the properties of the steel. Hitherto, British Codes of Practice have implied that the designer need only concern himself as to whether or not the vessel is operating above a temperature at which creep becomes a problem. Up to this temperature the design stress is based on the ultimate tensile strength of the steel at atmospheric temperature. The implication that the tensile properties of the steel are not influenced by temperatures up to the creep range has proved satisfactory only because the design stress of a quarter of the ultimate tensile strength at atmospheric temperature results in the use of an excessively great factor of safety. On the Continent the Codes of Practice have been revised in the light of modern knowledge so that substantially higher working stresses are used than would be permitted by the British Codes. According to Continental Codes of Practice design stresses are based on a combination of the ultimate tensile strength and the yield stress or 0.2% proof stress. Because this procedure results in a reduction of the factor of safety it is necessary to take into account the decrease in the strength of the steel with increasing temperature. In the majority of the foreign Codes of Practice and in the tentative code drawn up by the International Standards Organisation, design stresses are based on the 0.2% proof stress of the steel determined in a test carried out at the maximum temperature to which the steel will be subjected in service. In the case of carbon steels the 0.2% proof stress decreases rapidly over the temperature range 200 to 400°C. Due to the effect of the alloying elements, the reduction in 0.2% proof stress is much less in the case of *Ducol* W30 as is shown in Fig. 5.

Table 1. Effect of Type of Electrode on Heat-affected Zone Cracking in 'Ducol' W30

Electrode	*Thermal severity*	*Cracking*
Rutile coated Class 2	Up to and including 3	Nil
	4 and higher	Severe
Basic coated Class 6	Up to and including 12	Nil

Table 2. Effect of Preheat on Heat-affected Zone Cracking

Using Rutile Basic Electrode (B.S. 1719 Class 3)

Preheat	*Thermal severity*	*Cracking*
Nil	24	Severe
To 50°C. ..	24	Severe
To 100°C. ..	24	Nil
To 200°C. ..	24	Nil

Fabrication

Ducol W30 is intended to be used in the normalised and tempered condition and may therefore be hot-formed by the same processes as are employed for mild steel. However, it is desirable that more than the usual attention be paid to the temperature to which the steel is heated. Most Codes of Practice stipulate that boiler plates above about $1\frac{1}{2}$ in. thick should be in the normalised condition, implying that the steel is air-cooled from a temperature of about 900°C. to produce a reasonably fine ferritic structure. However, it is still found that some fabricators hot-form mild steel from a temperature as high as 1,200°C., which may result in the development of a structure at least as coarse as that of the as-rolled plate. Such a procedure should not, of course, be employed where the steel will be subjected to arduous service conditions and is therefore not permissible for *Ducol* W30. If forming cannot be carried out at a temperature within the range 850 to 950°C. it is essential that the formed plates be re-normalised from a temperature of about 900°C.

Welded pressure vessels are invariably subjected to a sequence of stress-relieving treatments during and on completion of fabrication. Such treatments, which involve heating the steel to a temperature of the order of 650°C., tend to soften the steel. In the case of mild steel in the 26 to 30 or 28 to 32-ton tensile ranges the reduction in strength should not be very great and ample allowance is made for it in the usual factor of safety. However, in the case of the higher-tensile carbon-manganese steels, the reduction might

have serious consequences. The alloying elements present in *Ducol* W30 steel have the effect of increasing the resistance of the steel to softening during the stress-relieving treatment. As an added safeguard the tensile tests are carried out on test coupons which have been tempered for 2 hr. at 650°C., this treatment having an effect equivalent to the normal stress-relieving processes.

Applications

At present the most promising field of application for a weldable alloy steel of this type is for the manufacture of very large vessels for which mild-steel plates would be excessively thick. An illustration of such a vessel is shown in Fig. 6.

The advantages to be gained from the use of the alloy steel are substantially greater where design is based on foreign Codes of Practice than is the case when the British practice is followed. This is illustrated by the results in Table 3 showing the design stresses permitted by different Codes of Practice for 28 to 32 tons/sq.in. tensile for mild steel and for *Ducol* W30. The advantage to be gained from the use of the alloy steel is only moderate if the design is carried out according to British practice. However, if the design stress is based on the proof stress, the use of the high-tensile steel permits a reduction in plate thickness of 40%. A Continental fabricator using *Ducol* W30 would use plates only half the thickness of mild-steel plates used by his British competitor who could derive little benefit from using the alloy steel. Such a comparison must give food for thought to all concerned with competing in the export market. With the introduction in Britain of Codes of Practice comparable to those which have now become the accepted standard on the Continent, the advantages to be gained by the use of a low-alloy steel will be much greater and it may be anticipated that its use will be extended to smaller vessels where it is desirable to keep weight down by employing a relatively high design stress. In this connection it may be pointed out that for plates in the thickness range 1 to 3 in. the minimum tensile properties guaranteed would be appreciably higher than those for thicker plates, thus enhancing the value of the alloy steel. It may well be claimed that in *Ducol* W30 steel the British pressure vessel industry has available a material as good as, if not superior to, any in production elsewhere in the world, and it is to be regretted that current design practice only prevents full advantage being taken of its exceptional properties.

Table 3. Permissible Design Stresses for Mild Steel and 'Ducol' W30

Steel	*Basis of deriving design stress*	*Design stress, tons/sq.in.*
Mild steel	$\frac{\text{U.T.S.}}{4}$	7
Ducol W30	$\frac{\text{U.T.S.}}{4}$	8½
Mild steel	$\frac{0.2\%\ \text{P.S. at } 250^\circ\text{C.}}{1.5}$	8¼
Ducol W30	$\frac{0.2\%\ \text{P.S. at } 250^\circ\text{C.}}{1.5}$	14

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Chemical Pumps

(*Concluded from page* 122)

materials have severe limitations. Manganese steel, unfortunately, is mostly ruled out due to the extreme difficulty of machining.

For abrasion only, solid soft rubber pumps give the longest life, but abrasion-resisting cast iron and special cast steels may also be expected to last an average of 1,000 to 1,500 operating hours even under severe abrasive conditions. Rubber linings are unsatisfactory because the lining will separate from the impeller periphery or the cut-water due to the high velocities at these places. Solid soft rubber pumps will also be restricted to fairly low heads, say maximum 100 ft., because the centrifugal forces plus abrasion at high flow velocities will damage the rubber at the blade exits.

For heads higher than 100 ft., only metallic materials of high abrasion resistance are really satisfactory and for cement slurries of high consistency (65% solids) special chromium steels are now available which will give a life of up to 6,000 operating hours. If corrosion is also present, chromium-molybdenum steels must be used, which will also give a life of 5,000 to 6,000 operating hours under the above conditions. Many slurries such as cement, bauxite, milk of lime and china clay slurries are non-corrosive, though highly abrasive and, if they require pumping heads higher than 120 ft., can only be dealt with by metallic materials owing to the material stresses generated. Pumps for such conditions embody a great amount of ingenuity, not only as regards materials of construction, but also shaft sealing and flow pocket problems and only a few makers have successfully applied their resources to solving them.

Conclusion

Space does not permit coverage of the many other new types of chemical pumps that are of interest to the chemical engineer, such as proportioning and metering pumps, hydraulically or pneumatically operated 'zero leakage' pumps, bellows or diaphragm pumps, high-pressure reciprocating pumps and rotary pumps.

It may be mentioned that proportioning and metering pumps will increasingly be used for automatic processes and great developments may be expected in this field.

Progress in Engineering

NEW INDUSTRIAL MACHINERY AND EQUIPMENT ON SHOW IN LONDON

At the Engineering, Marine, Welding and Nuclear Energy Exhibition, which is being held at Olympia, London, from April 16 to 30, there will be comparatively little chemical plant, since very few chemical engineering firms will be exhibiting. However, there will be a great deal of machinery and equipment equally essential to the chemical and process industries, and advance reports from exhibitors indicate that there will be quite a number of new and interesting items on view. A selection of the exhibits is briefly described below.

Two new **centrifugal pumps** are being displayed by the British LaBour Pump Co. Ltd. One is the type DSZ, a direct-mounting, horizontal, single-stage pump for all types of liquids and slurries. Direct mounting on to the driving motor eliminates the bearing bracket. It is claimed that the DSZ can handle large proportions of air or gases entrained with the liquid.

The other new pump, the MSZ, has been produced to handle hot liquids with capacities up to 1,000 gal./min., heads being available up to 300 ft. Pedestal mounted, it is designed for quick dismantling without disturbing the suction or delivery connections.

A **float trap** is being introduced by Midland Industries Ltd. in which the float leverage does not act through pivots but is made to roll on a convex surface. the valve block being constrained to travel in only one plane. A characteristic of this design is that the rate of valve opening increases with an increase in the flow of condensate and *vice versa*, thus providing a constant discharge when operating conditions are fluctuating.

A demonstration unit which can be seen operating on the stand of Carter Gears Ltd. will show the versatility of the company's **variable speed gear,** particularly with regard to cyclic speed changes for continuous industrial processes. The gear control will be continuously operated by a cam arrangement and independent tachometer drives will be included to show the constant input speed on the one hand and the infinitely variable output speed on the other. Other working units will also be exhibited, demonstrating standard controls for both 'A' and 'F' type Carter gears.

Exhibits by Graviner Manufacturing Co. Ltd. will include industrial **explosion protection and suppression** equipment, to which three new items have been added. One is a combined detector and suppressor unit which is designed for single-hold fixing and inerts and suppresses a volume of 500 gal. in less than 10 msec. Another is a high-speed butterfly valve, developed as a more economic alternative to the high-speed isolation valve. This valve finds its chief application in air or gas systems. It is used to retain suppressant or inerting concentrations in systems where the normal air or gas flow would otherwise purge the system before fans or blowers can be brought to rest. The valve is also used in dust systems for explosion isolation.

The third new item is a photo-electric explosion detector for use in explosion suppression or protection systems where operating conditions do not allow the use of detection by pressure methods. It is available in air-cooled or water-cooled versions (for applications where the normal plant operating temperature exceeds 50°C.) and is suitable for use in gaseous or dust explosion risks.

An unlubricated **valve** with a stainless-steel body and PTFE-sleeved plug is being featured by Audley Engineering Co. Ltd. It is suitable for a maximum working pressure of 50 p.s.i. at a maximum temperature of 100°C. and is available in ½- to 4-in. sizes.

Also to be shown is the *Audco Annin* control valve, developed for controlling hot, cold, erosive, corrosive and viscous fluids, and both manual and power-operated examples will be on view. They are made in a range of sizes from ¾ to 8 in. and in a variety of materials of construction.

A representative selection of *Audco* manual and power-operated lubricated taper plug valves will be shown in a variety of materials and in sizes ranging from ¼- to 24-in. bore for controlling pressures from fine vacuum up to 5,000 p.s.i.

Vokes Genspring Ltd. will be showing 'M' type constant **support hangers** for pipes and ducting in nuclear power stations, refineries, chemical plants, etc. Variable support hangers for similar applications, but less critical conditions than those requiring the 'M' type, will also be on view. Sway braces which are particularly suitable for the protection of large steam lines, feed-water lines, exhaust, compressor and hydraulic lines, from shock or vibration will be among other exhibits.

A model will introduce a new type of support which will be used on CO_2 cooling circuit ducting at the Hinkley Point nuclear power station. It is capable of supporting a load of 90,000 lb. over a vertical movement of 4 in. travel. Another type supports 45,000 lb. over a 4-in. vertical movement. Both these supports are capable of accommodating vertical travels of up to 12 in. with reduced loading.

A diaphragm-operated **automatic return valve,** consisting basically of a seatless piston valve operated by a diaphragm fed from a low-pressure air supply, will be one of the chief exhibits of Richard Klinger Ltd. This valve is suitable for remote control and by a simple change of an internal part can be made to open or close automatically upon failure of the operating air supply.

Another adaptation is an internal modification that can be fitted to any *Klingerflow* valve up to 2-in. bore, to give the valve a much finer degree of flow control than hitherto.

Replacing the existing oil-sealed valve suitable for

vacuum, a modification incorporating rubber O-rings in place of the more usual C.A.F. valve rings will provide a valve particularly suited for service with very high vacuum conditions, again available up to 2-in. bore.

A new **variable speed gear unit** specially designed for vertical mounting is to be exhibited by Allspeeds Ltd. It is provided with a separate oil sump casting located on the lower flange. The necessity of using oil seals on the lower shaft has been overcome by incorporating a labyrinth and flinger arrangement which cannot deteriorate in service or allow any oil to leak down the shaft. Hitherto, due to the splash method of lubrication, the standard model has been suitable only for mounting horizontally.

The oil is circulated from the sump into the upper bearings by means of a *Suddo* pump, mounted over and driven by the upper shaft of the electric motor, and passes down through the unit back to the sump. The unit is particularly suited to stirring and agitating applications in the food and chemical industries.

A new **valve diaphragm** of PTFE, exceptionally resistant to chemical attack and able to withstand normal vacuum conditions or a working pressure of 100 p.s.i., will appear on the stand of Saunders Valve Co. Ltd. Grade 214, as it is called, is available in sizes from ½ to 4 in. for almost all chemicals at temperatures up to 150°C.

Valves being exhibited by the same company include plastic valves for duties in acid-laden atmospheres. For the first time the spherical plug type ' M ' valve is available in eight sizes from ½ to 3 in.

The main exhibit of Film Cooling Towers (1925) Ltd. will be a small, induced-draught **cooling tower;** one of a new range of polyester resin-bonded glass fibre units, with an access panel of *Perspex* to enable the *Film Flow* grid packing to be seen in operation. Examples of induced- and natural-draught towers erected in timber and reinforced concrete will also be illustrated.

Valves for the **flow control of piped solids** such as flake gelatine, cement or grain, are being exhibited by British Steam Specialities Ltd., with their flexible sleeve *Mucon* range. The principle is similar to that of the shutter of a camera, the flexible diaphragm forming a concentric aperture which may be infinitely varied by a rachet handle at the side.

The valve is designed to control dispensing into sacks or bins from bulk storage. It is suitable for many diversified materials, and problems like bridging or cavitation can be solved. It may also be used in conditions of vacuum and, with the right diaphragm materials, will handle the flow of air or gases. A modified version will also deal with water under low pressure.

The Holmes-Kemp **drier,** to be shown by W. C. Holmes & Co. Ltd., is of the totally enclosed, solid desiccant type designed to give continuous moisture extraction from air or other gases. It operates on a pre-set cycle, the period of drying being followed by one of heating then cooling to drive off the adsorbed moisture. Twin towers enable continuous drying to be carried out, one being in the process of reactivation while the other is drying. Several types of desiccant may be used. Pre-filters are fitted where the gas to be handled is laden with oil mist or other impurities.

The Holmes-Schneible **multi-wash system,** also on show, is applicable to a wide range of dust collection and control problems involving liquid and solid particles. The multi-wash collector has an efficiency of the order of 99% for all particles above 3 to 4 microns. Having a lower pressure drop than many wet washers, and an absence of circuit restrictions which might cause blockages, this economic collector provides trouble-free operation.

Stainless-steel **bellows for expansion joints,** suitable to a wide range of specialised applications in the nuclear, gas, petroleum, marine, chemical and general engineering fields, will be shown by Teddington Aircraft Controls Ltd. The company will also show a new range of rectangular units, some measuring 24 ft. × 24 ft., for flues and boiler uptakes on large land boiler installations at power stations in the U.K. An even larger installation is on the board, using segments of the expansion joint which will weld together on site to make a roughly circular assembly 78 ft. in diameter.

Self-cleaning filters made by Zwicky Ltd. and known as *Zwickleen* are being shown in a range of ½- to 2-in. bore size and three degrees of filtration, 0.003, 0.006 and 0.010 in. One complete turn of the handle removes the accumulated dirt, causing it to fall into the sump, which is easily removed for periodic cleaning. The standard filters are suitable for use with lubrication and fuel oils but can be manufactured for other purposes.

The company is also showing NZ type filters, manufactured in ½- to 12-in. bore sizes of the gauze type. The dual pattern is intended for use in installations where continuous duty is essential and the direction of flow may be changed without any interruption when cages are removed for cleaning. Materials of construction and mesh may be altered to suit various liquids and pressures.

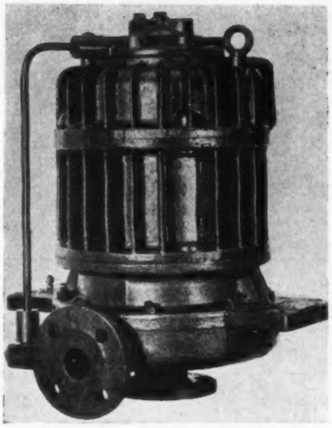
Self-opening **purifier/clarifier separators** for the treatment of heavy fuel oil for diesel engines, gas turbines and free piston machinery will be seen on the stand of Alfa-Laval Co. Ltd. Types PX.309-15F. and PX.207-19S. are to be shown, together with the *De Laval* purifier/clarifier system using VIB.1929.C. equipment and the larger capacity type HVB.210.00 equipment. Standard purifiers for diesel oil and purifiers with stainless-steel bowls for the treatment of lubricating oil for all diesel, turbine and free piston engined vessels are included, as well as special equipment for the treatment of turbine lubricating oil and insulating oil in power stations. Different types of plate heat exchangers used in the chemical and process industries are included.

A metal filter cloth produced by electroplating will be amongst exhibits on the stand of the Mond Nickel Co., which will feature the properties of various **metals** such as nickel, nickel-containing materials, platinum and *S.G. Iron.* It will include demonstrations of the creep-resistance of the platinum metals, sub-zero properties, integral-sheath thermocouples, and apparatus for testing the corrosion resistance of materials under thermal load.

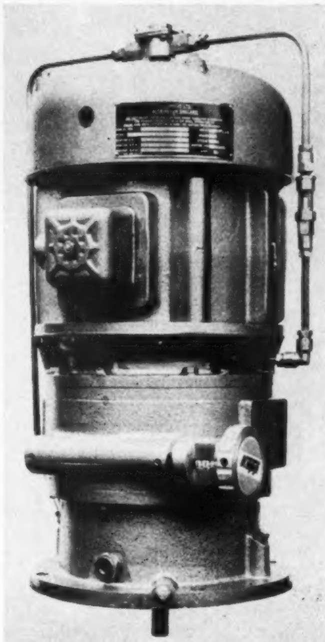
Vacu-Blast Ltd. will be exhibiting four of their mobile, dust-free **shot-blast machines.** The *Major*, with pipe-cleaning attachments, the *Medium* and the *Junior* machines will be available for demonstration throughout the exhibition. The display will also include attachments for plate edge cleaning and blast cabinets for use with *Vacu-Blast* machines.

The *Vacu-Blast* incorporates a closed circuit pressure-vacuum system for the supply of abrasive to the work

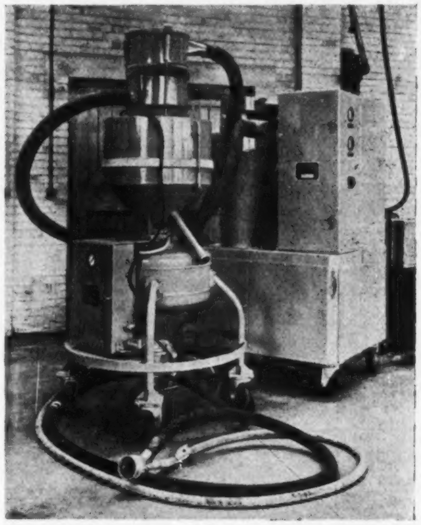
PICTURE PREVIEW OF THE EXHIBITION



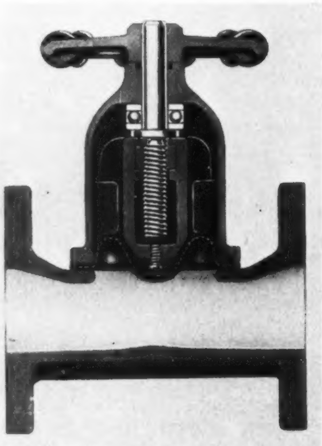
One of the glandless hermetically sealed canned-motor process pumps, type CM, by K.S.B. Manufacturing Co. Ltd.



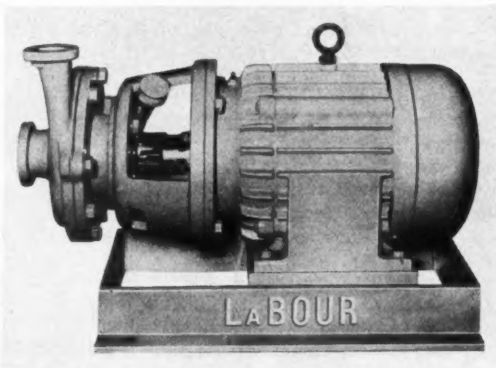
The Kopp vertical mounted variable speed gear unit, to be exhibited by Allspeeds Ltd., is well suited for stirring or agitating.



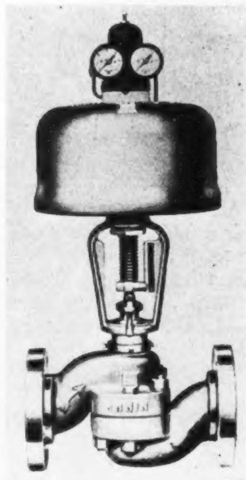
The Major Mark II shot-blast machine exhibited by Vacu-Blast Ltd., filters the finest particles of dust from the exhausted air.



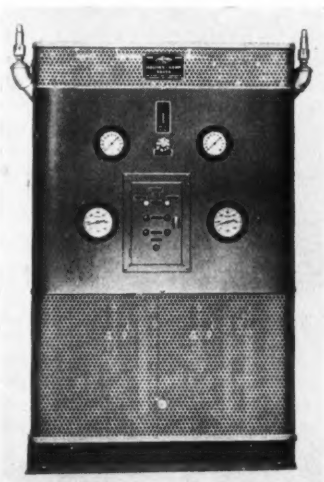
A type KB straight-through valve with a pressure-closing operating head, shown by Saunders Valve Co. Ltd.



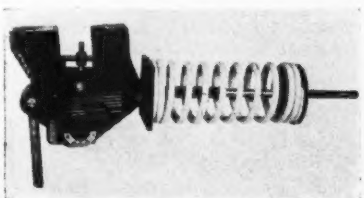
Direct-mounted DSZ pump, one of two new centrifugal models by British LaBour Pump Co. Ltd.



Audco Annin Domotor control valve for erosive, corrosive and viscous fluids.



Left. **The Holmes-Kemp totally enclosed solid desiccant continuous drier to be shown by W. C. Holmes & Co. Ltd.**



Right. **One of the 'M' range constant support hangers by Vokes Genspring Ltd. gives careful control of stresses and strains.**

surface and recovery of spent abrasive, dust and debris. The machine separates and cleans the abrasive, the dust and debris being abstracted from the air stream, with the finest particles of dust finally filtered from the exhausted air.

Besides its use on ferrous metals, *Vacu-Blast* can be used successfully on aluminium alloys, *Nimonic* alloys, yellow metal alloys, *Durestos* material, resin-bonded lamina and practically any thermosetting plastic.

Machines which can be used both as **compressors** and as **vacuum pumps** will be displayed by B. A. Holland Engineering Co. Ltd. They range from 1 to 300 h.p. and two-stage machines, having two compressors one after the other, permit high degrees of compression. On this stand, rotary compressors, vacuum pumps and blowers will be shown and there will be a working sectional model showing the cellular compression effect achieved by the vanes.

Lobe-type compressors for low-pressure duties are among other products of this company.

Process pumps with standardised components will be among the exhibits of K.S.B. Manufacturing Co. Ltd. The CH range have a volute casing with end suction and radial discharge. For pumps up to medium size, these parts are cast as one so that in dismantling the casing can remain undisturbed on the pipeline. A series of glandless, canned-motor process pumps, type CM, will also be seen. Pump and motor form a single unit without any gland. The motor rotor is surrounded by the liquid and the rotor and stator windings are sealed against the liquid by pressure-tight sheaths.

Automatic equipment for the **welding** of mild steels and stainless steels will be demonstrated on the stand of Murex Welding Processes Ltd., where exhibits will include welding electrodes for both hand and automatic welding, and fluxes, as well as welding power packs, mobile equipment and welding accessories.

The *Muramatic* welding head has been designed for use with either the submerged-arc or open-arc process using either a.c. or d.c. supply, and with welding currents of up to 1,200 amp. Attached to the head is the control panel with all the necessary electrical controls and instruments grouped together, thus permitting the operator to vary the current, voltage and various 'stop,' 'start' and speed controls as required.

CPE WILL BE THERE

CHEMICAL & PROCESS ENGINEERING *will be exhibiting on Stand No.* 26, *in the Inner Row of the Gallery. The editor and staff offer a warm welcome to all readers.*

A new **pipe coupling** to be introduced at the exhibition has been developed for high-pressure hydraulic installation work but is stated to be suitable for many other applications. Oil pressure is used to form the tube end to a special shape in which there is a bulged portion. When the coupling is tightened an 'O' ring is expanded gently as it passes over the tube, finally seating on a section of the tube adjacent to the bulge. The bulged portion serves to clamp the tube end firmly in the coupling.

The exhibitors of this coupling, Industrial Hydraulics Ltd., say that it may be used with any of the usual metal tubes and is available for a wide range of fluids and operating conditions.

INDUSTRIAL PUBLICATIONS

Glass sink traps and waste lines provide an efficient means of disposing of noxious liquids from chemical, pharmaceutical and biological laboratories. Equipment of this type, fabricated in chemically resistant borosilicate glass, is described in an illustrated, 24-page catalogue by Q.V.F. Ltd., Duke Street, Fenton, Stoke-on-Trent, Staffs. Various types of sink traps are described and information is given on waste lines from ⅜ to 6 in. bore, as well as on fittings, methods of assembly and support.

Alkoxides. The properties and applications of dry alkali metal alkoxides are summarised in a 35-page booklet from Feldmühle A.G., Burggrafenstrasse 7, Düsseldorf, Oberkassel. Their use as catalysts in condensation reactions (Claisen type), transesterification, saponification, polymerisation, isomerisation and other processes is discussed and literature references are given.

Gas from oil. A paper presented to the Institution of Gas Engineers by A. S. Taylor and G. Milner deals with some methods of making gas from oil and is issued in pamphlet form by the Power-Gas Corporation Ltd., Stockton-on-Tees. The paper is well illustrated with diagrams and flow charts of plant and processes. Also published by Power-Gas is an illustrated brochure explaining, in English, French, Spanish and German, how the Group is organised into divisions to deal with chemical plant, petroleum plant, gas plant, general engineering contracts, fabrication, blast furnaces and oils-and-fats specialities.

Hydro-extractors. A suspended, pitless, electrically driven hydro-extractor, available in various sizes between 18 and 60 in. diam., is described in a pamphlet from Power Installations Ltd., Tudor Works, Bradgate Street, Leicester. Another type for the smaller user or for testing purposes is the subject of another pamphlet.

Nitrile rubber latices. The *Hycar* series of oil-resisting synthetic copolymers of butadiene and acrylonitrile. Technical booklet H.1 from British Geon Ltd., Devonshire House, Piccadilly, London, W.1, deals with latices used for the impregnation, coating and printing of textiles, as adhesives, as finishes for leather and in coatings where oil resistance is essential.

Mechanical seals for every service are described in an illustrated catalogue-cum-reference book issued by the Mechanical Seals Division of Crane Packing Ltd., Slough. The contents include seal installations and design, temperature and pressure charts, seal selection guide, breakout torque and horse power absorbed graphs—based on actual running experience—and a component material guide covering over 500 fluids.

WHAT'S NEWS about

★ Plant
★ Equipment
★ Materials
★ Processes

This illustrated report on recent developments is associated with a reader service that is operated free of charge by our Enquiry Bureau. Each item appearing in these pages has a reference number appended to it; to obtain more information, fill in the top postcard attached, giving the appropriate reference number(s), and post the card (no stamp required in the United Kingdom).

Condensers for heaters

The vapour-cooled *Vapotron* valve, used in power circuits in industrial electronic heating equipment, is now to be provided with a glass-fibre boiler condenser in place of the metal condenser previously used, Siemens Edison Swan Ltd. announce.

Boiler condensers using this new material are being used with valves of up to 40-kw. output. The *Vapotron* is not water-cooled in the usual sense, but relies on the vaporisation of water for its cooling. **CPE 1199**

Will have more on its plate(s)

New uses for their double-effect, plate-type evaporator are envisaged by A.P.V. Co. Ltd., who report that, following its success in the dairy industry, the evaporator has been called for by industries evaporating fruit juices. It has also been used with success for the concentration of glucose. The company has set up a full-scale testing plant for trying out different products. With a capacity of 1,000 lb./hr. the plant is of the double-effect type and is fully instrumented so that accurate quantitative data can be obtained.

This type of evaporator uses plates on the climbing- and falling-film principle instead of tubes. **CPE 1200**

Hydraulic testing on site

Everything needed to carry out a hydraulic pressure test on site is included in a portable set by Charles S. Madan & Co. Ltd., which only needs to be connected to a compressed-air supply of not more than 100 p.s.i. Where necessary it may be operated from nitrogen or compressed-air bottles.

The pump works on the principle that the air pressure applied to a large air piston imparts a thrust to a hydraulic ram of smaller area and creates a high hydraulic pressure. This reciprocating action gives a continuous flow. An air pressure regulator control valve enables all intermediate hydraulic pressures within the range of the pump to be accurately determined and makes it safe for the operator to leave the item under test. On reaching the necessary pressure the pump becomes dormant on a closed circuit, using no further air. Should there be intermittent leakage from the component or circuit under test, the pump will move automatically until the loss is made up.

The test set comprises an *Air-hydropump*, air pressure regulator, air filter, hydraulic filter, air and hydraulic gauges, hydraulic stop valve and six assorted adaptors for various B.S.P. connections. The set is fitted in a moulded glass-fibre case which, when inverted, becomes a 5-gal. reservoir supplying the pump. **CPE 1202**

BIG, BUT ROOM FOR EXPANSION

This is one of the largest-ever circular rubber expansion joints with an inside diameter of 10 ft., constructed from ply upon ply of rubber-impregnated canvas covered with specially moulded abrasion-resistant rubber. It is one of three made by George MacLellan & Co. Ltd. Rectangular joints up to 18 ft. have been made by the company.

Advantages claimed for rubber expansion joints include low weight, no electrolysis when used in connection with salt water, and elimination of gaskets. In general they give flexibility to pipe or ducting systems, allow natural compression, tension, shear and out-of-line stresses to be accommodated and reduce vibration, transmission of noise and damage from shock. **CPE 1201**

Packing extractors for nothing

A stuffing box in which vestiges of an old, worn gland packing remain is frequently the cause of premature failure of the new packing. The same conditions are an even more frequent reason for the failure of a gland packing properly and efficiently to seal against leakage. When it is necessary to remove an old, worn gland packing, properly designed extractor tools are indispensable.

This point is made by Crane Packing Ltd., and to emphasise the importance of using the correct tools the company are offering to supply free of charge a pair of 7-in. packing extractors. *Bona fide* users of gland packings who would like to test these tools should write to the company or fill in the CPE reply-paid card. **CPE 1203**

Saves on smoke

Smoke eliminators, used particularly for industrial boiler plant, are manufactured by Lynward Engineering Co.

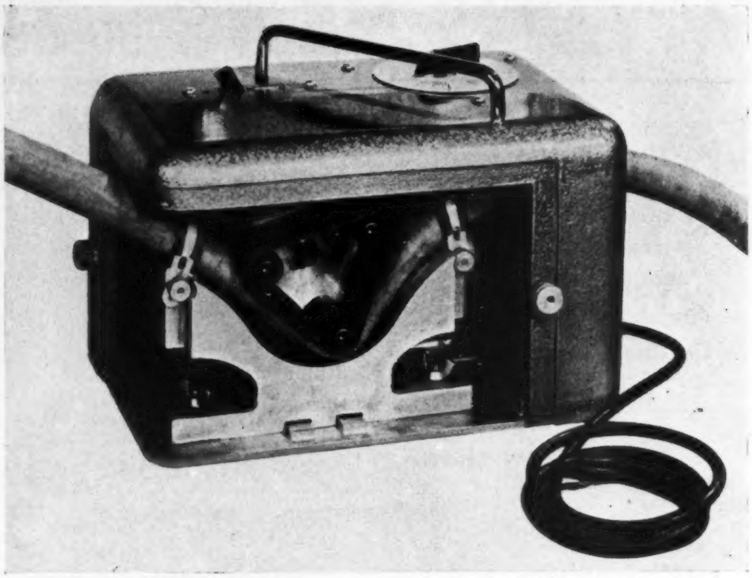
Ltd. Two types are currently available, one for natural-draught, hand-fired boilers, and the other for similar boilers with forced draught.

Apart from ensuring that smoke emitted conforms with statutory obligations, these eliminators are claimed to effect substantial savings. **CPE 1204**

Hot wax gets a rise

The modernisation programme recently completed at the London works of Price's Patent Candle Co. Ltd. involved the installation of two *Megator* M50 pumps for handling paraffin wax. In the factory, wax is heated by open steam coils in tanks of 9 tons' capacity below the level of the boiling-house floor. After filtering it is pumped to blending vats 30 to 40 ft. above the boiling-house floor for admixture of sulphuric acid and purification by steam agitation. This is where the two pumps, supplied by Megator Pumps & Compressors Ltd., come in. The pump bases are heated externally by steam and internally by electric tubes. All pipelines are traced with heating cable to keep the wax at a temperature of 160 to 180°F. to prevent it solidifying and all heating is on permanently. The removal of a single cover plate on each pump provides access to all working parts for inspection and servicing.

Vat replenishment occupies the pumps a total of 2 to 3 hr. a day, operating at an output of 9 tons/hr. Depending on the level in the tanks, the input varies from gravity feed to slight suction lift. The control console is directly above the pumps at main floor level and includes the starting switches for the pumps and controls for distribution to the three main vats. From the vats the wax is gravity fed to steam-heated jacketed pans. **CPE 1205**



The rollers of this 'HR' flow inducer flatten the pipe at the point of contact only without kinking or interfering with the flow.

Coating work made 'Plasinter'

Bonding of polythene and other plastics to ferrous or non-ferrous metal by the *Plasinter* process is claimed completely to overcome peeling. It is suitable for wire work, tubular steel assemblies, sheet metals, aluminium ware, brackets, castings, etc.

These coatings of polythene, PVC, PTFE, PTFCE and nylon, applied by the Darleston Galvanised Holloware Co. Ltd., withstand sterilisation in boiling water, make metals non-toxic, add strength and increase corrosion resistance. With the *Plasinter* process disadvantages such as porosity and induction of static electricity have been largely overcome. **CPE 1207**

PUMPLESS PUMPING

A means of inducing the flow of fluids, from slurries to gases, through pipes without the intervention of any extraneous device is provided by the Watson-Marlow Air Pump Co.'s 'H.R.' flow inducer. A flexible, *Fluon*-lined pipe is clipped to a multi-curved track, which is locked into the machine, when the central curve is concentric with a rotor bearing three rollers.

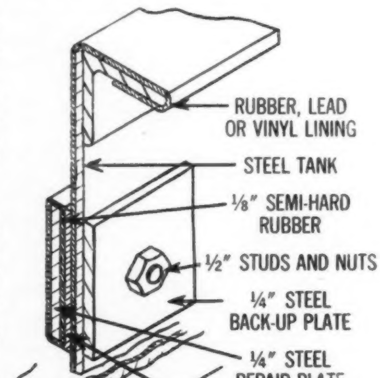
The rollers pass over the pipe, flattening it against the track at the point of contact only. This 'flat' accordingly moves round the central curve of the track driving anything in the pipe before it. At the same time the restitution of the pipe behind the roller creates a powerful suction, drawing in more fluid to be pushed by the following roller.

The multi-purpose pipe track has been designed to give a positive flow induction over the central concave portion and full support to the pipe at either side without kinking or interfering with the flow. The pipe follows a virtually straight path in both directions from the roller and the only limit to the size of pipe used is the width of the track. Besides providing adjustment for pressure and flow, the polished aluminium track is instantly removable for changing or cleaning.

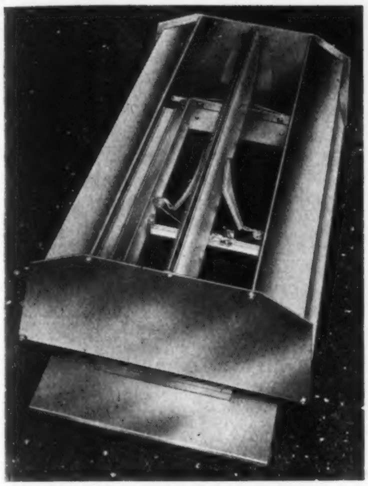
The direction of flow is reversible and controlled by a three-position switch. The flow rate is variable from a few cubic centimetres a minute to about 500 gal./hr. by varying the rotor speed and the size of pipe. The rollers are made of nylon and are filled with molybdenum disulphide. A sheet aluminium cover is removable for access to the pipe track. **CPE 1206**

On-the-spot repairs for acid tanks

Leaking lined acid tanks can be repaired in position with the *Camac* repair plate. The plate is covered with ⅛-in.-thick semi-hard rubber and



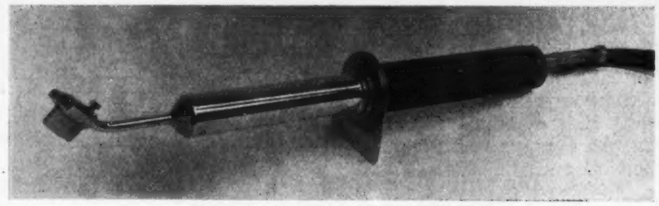
How lined acid tanks are repaired.



LETS IN THE AIR

This special, flap-opening ventilator is a natural-extract unit which can be used to boost air change in summer time. It is made by Colt Ventilation Ltd. who produce a variety of ventilators in durable aluminium, these being controllable by pneumatic, screw-rod, electrical or cord controls. The same company produce dual-purpose ventilators which can be operated for daily ventilation by manual control but which, in the event of fire, will sound an alarm and instantly, by fusible-link mechanism, open to release smoke, noxious gases and heat, thus facilitating fire-fighting and the escape to safety of the occupants.

CPE 1208



FOR JOINING PLASTICS

Light and well-balanced, this electrically heated Gee-Bee *welding torch for polythene and PVC incorporates a virtually unbreakable heater element which can be exchanged in a matter of seconds. The element reaches its maximum temperature within* 10 *min., the welding gas emerging at a temperature of* 280 *to* 300°*C., measured* $\frac{1}{8}$ *in. from the nozzle tip, with the welding gas adjusted to a flow of* 20 *l./min. at* 5 *p.s.i. The built-in support enables the torch to be rested on the work-bench without danger of burning it, while another feature is that the nozzles supplied with the torch carry knives for cutting off filler-rods and for other operations on thermoplastics. Transformers for use with these torches are available from the suppliers, Goodburn Plastics Ltd.* **CPE 1211**

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a $\frac{1}{4}$-in. soft-rubber gasket is vulcanised on the tank side of the plate. The repair plate is complete with studs, nuts and back-up plate.

The back-up plate is used as a template and the tank is drilled from the lining side with a $\frac{9}{16}$-in. drill. Studs are inserted on the back of the repair plate through the holes, and the back-up plate is placed over the studs and the nuts tightened to complete the repair. No solvents or cements are required. The manufacturers are Carl Buck & Associates. **CPE 1209**

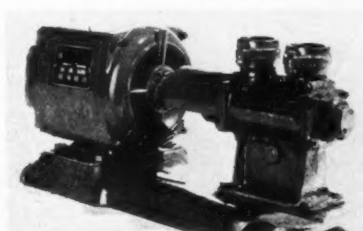
Lightweight pump set

Useful, among other things, for emptying vats and barrels completely is a new process pumping set which can run silently with a dry suction for long periods. It comprises a Goodyear size A5 positive-displacement pump coupled to a Newman *Elf* $\frac{3}{4}$-h.p. a.c. electric motor mounted on a lightweight aluminium bedplate casting. The pump, with a normal operating speed of 1,440 r.p.m., delivers 5 gal./min. of water and is completely self-priming. It can also handle viscous fluids and fluids which contain suspended solids.

The rubber-to-metal type pump has only two moving parts in contact with the liquid, the plate wheel and rotor. The taper roller bearings are grease packed, and radial face shaft seals are fitted which do not cause the shaft to wear as they become due for renewal.

The set with a *Meehanite* pump weighs 46 lb., and is $20\frac{1}{2}$ in. long, $7\frac{1}{4}$ in. wide and $9\frac{1}{2}$ in. high. Pumps in bronze, light alloy or stainless steel are also available from the makers, Goodyear Pumps Ltd. **CPE 1212**

Automatic distillation apparatus.



Pump set with aluminium bedplate.

TEN-MINUTE DISTILLATION

Automatic distillation apparatus which carries out, in a matter of minutes, an operation for the routine testing of refinery products, which normally takes the best part of an hour, is being manufactured by F. J. Hone & Co. Ltd., under licence from the British Petroleum Co. Ltd. The BP-Hone apparatus is based upon a distillation method for testing when the value of a single point on the distillation curve provides sufficient information for day-to-day volatility control.

The operation requires the introduction by pipette of 10 ml. of the sample into a flask. A thermocouple is inserted into the neck of the flask and the receiver is placed in position. The heater is then switched on and, when the selected temperature is reached, is cut off automatically. The volume of the distillation to the nearest 0.05 ml. is then noted, after allowing half a minute for draining. After each distillation, the residue in the flask is removed by suction. The complete operation takes no longer than 10 min., of which less than 3 min. is operator's time. **CPE 1210**

INDUSTRY REPORTS...

Research on prussic acid

Important progress in the manufacture of active oxygen compounds was mentioned in the annual report of Degussa, the German precious-metal and chemical concern. Prussic acid was manufactured in two different processes, while a new plant for cyanuric chloride—a derivative of hydrocyanic acid—was taken into service during the year. Efforts are being made to open up new fields of application for prussic acid.

Fertilisers in Israel

An extension programme which will double the nitrogen production facilities and provide liquid and compound granulated fertilisers has been embarked upon by Fertilizers & Chemicals Ltd., Israel. The capital expenditure will be of the order of I£12 million.

This is revealed in the company's annual report which comments that domestic demand for nitrogenous fertilisers are forecast to exceed in the year 1960-61 the present designed capacity of the factory by 65%. It is therefore planned to increase the output of ammonia to 20,000 tons p.a. by 1960, and to raise this quantity subsequently up to 26,000 tons. A partial oxidation plant is under construction which will supply additional raw materials required for an increased output of ammonia.

It is also planned to initiate the production of liquid fertilisers in higher concentrations and of compound and concentrated fertilisers. Ancillary facilities such as steam, boiler water, cooling water and power supply will be expanded to this end. Carbon dioxide, a by-product of ammonia manufacture, will be used as raw material in a dry ice plant, for which equipment has been ordered in Germany. This plant is designed to produce 12 tons of liquid carbon dioxide daily, half of which will be marketed as dry ice.

Work on sites for the extensions began in April 1958, and it is hoped to run in the new plants before the end of 1959.

Oil and gas in U.S.A.

Optimism about the outlook for the year ahead, based principally upon the recovery in the national economy as a whole and particularly within the oil and gas industries, is expressed in a letter from Dresser Industries Inc., U.S.A., addressed to shareholders. It points out that, in January, total refined product demand was about 10% higher than a year ago. To meet this demand, refinery runs were increased, resulting in a healthy reduction in crude oil inventories. In fact, crude inventories are nearly 30 million barrels or 10% below a year ago. Moreover, the increase in refinery runs did not result in a potentially dangerous accumulation of gasoline.

Inflationary trend in U.S.A.

The dangers in the 'wage-cost-price inflation' were emphasised in the annual report of Mr. C. H. Greenewalt, president of the Du Pont Co., U.S.A. He pointed out that, before the second world war, advances in technology made possible by Du Pont research and development more than offset increases in the elements of manufacturing cost. It was thus possible to maintain competitive wages and salaries and a satisfactory return on their operating investment while prices were being reduced. In the post-war years, however, the increase in wages and salaries made it difficult for improved technology to keep pace. In 1958 the Du Pont average weekly wage was 71% above the 1947-49 average, a rate of increase of 5½% p.a., which more than offsets advances in technology arising from research and development activities during the period. In consequence, the company's sales price index showed only a modest increase of 5%, compared with the advance of 23% in the U.S. Bureau of Labour statistics consumer price index.

The report disclosed that Du Pont achieved a record expenditure of $231 million during the year for new plants, increased capacities at existing plants, and for service and laboratory facilities, compared with $220 million in 1957. In 1958, the average gross operating investment increased $160 million to a total of $2,581 million.

£ s d

CHEMICAL PLANT COSTS

Cost indices for the month of February 1959 are as follows:

Plant Construction Index: 179.0

Equipment Cost Index: 165.2

(June 1949 = 100)

£ s d

Chemical, gas and petroleum plant

Renewed activity in the chemical plant field was reported by Mr. W. R. Brown, D.S.O., chairman of the Power-Gas Corporation Ltd., in his statement for the year. Orders had been booked for most of the company's speciality plant lines, *e.g.* gas reforming, CO_2 production, sulphuric acid, glycerine, crystallisers, etc.

Orders for gas plant were secured in six different countries and the volume of business could well have been larger had it not been necessary to surmount technical difficulties connected with the gasification of a wide variety of oils. The company is supplying part of the high-pressure plant for gasifying coal in Scotland by a process which may prove suitable in other coalfield areas. The research department was investigating the detoxification of gas.

The building of gasholders suffered from 1958 Government policy in the U.K. which limited expenditure in the gas industry, 10 orders for gasholders were secured elsewhere and 14 others were completed during the year.

Mr. Brown also reported that the new factory extensions were virtually complete and in production. It was 10 years since the company made the decision to re-plan almost the whole of its manufacturing facilities and build afresh an entirely modern factory on a new site. The Power-Gas chairman also referred to the recent formation, with John Thompson & Co. Ltd. and Humphreys & Glasgow Ltd., of a new company, Nuclear Chemical Plant Ltd. This new company will be concerned with the design and engineering of process and treatment plant for the nuclear industry.

Potash production and prices

Overproduction in the potash industry in America, leading to substantially lower selling prices, was referred to in the annual review of Lord Clitheroe, chairman of Borax (Holdings) Ltd. He also drew attention to a new source of competition in Canada, where rich beds of potash have been discovered, albeit over 3,000 ft. below the surface, and where other companies were initiating potash mining and refining activities in Saskatchewan.

Earlier in his review Lord Clitheroe attributed the disappointing year to the unsatisfactory results of the United States Borax & Chemical Corporation, which continued to experience difficulties, both at its new plant at Boron, California, and in the potash field.

NOMOGRAM

By D. S. Davis

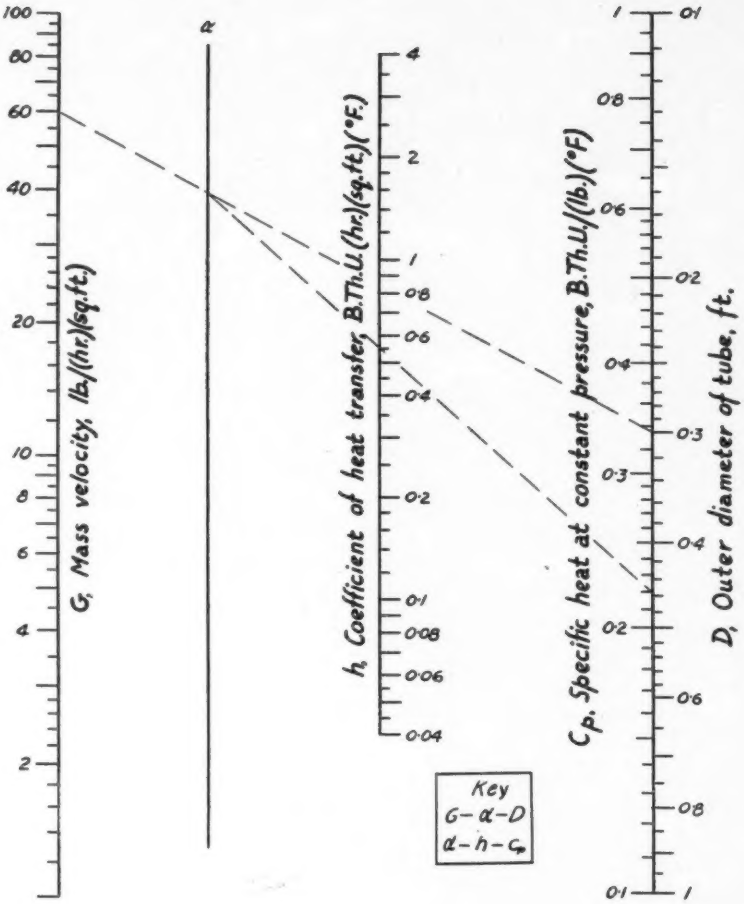
Heating and Cooling of Gases Flowing Normal to Staggered Tubes

For heating and cooling of gases flowing normal to a 10-row bank of staggered tubes, McAdams[1] recommends the equation

$$h = 0.133\, c_p\, G^{0.6}/D^{0.4}$$

where h = heat transfer coefficient, B.Th.U./(hr.) (sq.ft.) (°F.); c_p = specific heat of gas at constant pressure, B.Th.U./(lb.) (°F.); G = mass velocity of the gas, lb./(hr.) (sq.ft.); and D = outer diameter of the tubes, ft.

The accompanying nomogram, which was constructed by means of methods described previously,[2] enables one to solve the equation readily and accurately. Use of the chart is illustrated as follows: What is the heat transfer coefficient when a gas with a specific heat at constant pressure of 0.220 B.Th.U.(lb.) (°F.) flows normal to a 10-row bank of staggered tubes with outer diameters of 0.300 ft. at a mass velocity of 60 lb./(hr.) (sq.ft.)? Following the key, connect 60 on the G-scale and 0.300 on the D-scale with a straight line and mark the intersection with the α-axis. Connect this point and 0.220 on the c_p-scale with a straight line and read the desired heat transfer coefficient on the h-scale as 0.55 B.Th.U./(hr.) (sq.ft.) (°F.).



REFERENCES

[1] W. H. McAdams, 'Heat Transmission,' 3rd ed., p. 275. McGraw-Hill Book Co. Inc., New York, 1954.

[2] D. S. Davis, 'Nomography and Empirical Equations,' Chap. 6. Reinhold Publishing Corporation, New York, 1955.

Anti-pest show

Leonard Hill Ltd. announce that the next International Crop Protection and Pest Control Exhibition, organised by *World Crops*, will be held from Wednesday, December 9, to Friday, December 11, 1959, at the Seymour Hall, St. Marylebone, London, W.1.

The aim of the exhibition is to cover all aspects of crop protection and pest control including insecticides, pesticides, tree bands, fumigants, rodenticides, herbicides and weedkillers, fungicides, sprayers and applicators of all kinds, cloches, seed treatments, traps, slug killers, insect repellants, bird repellants, timber preservatives and treatments, protective fencing, bird netting, disinfectants, aerial spraying and other protective services.

Further details can be obtained from the Exhibition Organiser, *World Crops*, Leonard Hill House, Eden Street, London, N.W.1.

High-pressure, high-temperature materials

Studies in hitherto largely unexplored aspects of materials research are under way at Battelle Memorial Institute, Columbus, Ohio, using equipment designed to give a combination of ultra-high pressure and temperature. Although previous materials research has utilised both pressure and temperature independently, the combination of pressure and temperature provides a relatively new area for investigation.

The latest of four high-pressure, high-temperature cells developed at the research centre has just been completed. This newest cell will be capable of handling specimens up to ¼ cu. in. in size. The other three, developed over a two-year period, have produced reactions at temperatures in excess of 5,000°F. and at pressures in excess of 1 million p.s.i. The cells have been designed to operate at much greater pressures and have provided pressure well in excess of 2 million p.s.i.

Company News

Pennsalt Chemicals Corporation, U.S.A., is to have manufacturing, sales, and technical service in Europe handled by Pennsalt International Corporation S.A., Lausanne, Switzerland, who will introduce a range of speciality chemicals.

*

A Swiss sales company, Du Pont de Nemours International S.A., with headquarters in Geneva, has been formed by the parent American company to help plan and implement European sales for products to be manufactured by Du Pont subsidiaries in Europe, and for many products manufactured in the United States by the parent company.

The company's first European plant, near Londonderry, Northern Ireland, to manufacture neoprene synthetic rubber, is due to operate in 1960, and their first plant on the Continent is now being built in Malines, Belgium, to produce paint, with completion scheduled for later this year.

*

Chemical Construction (G.B.) Ltd. have completed a licencing agreement enabling them to offer the Svenska-Flaktfabriken venturi scrubber in addition to their Pease-Anthony venturi and cyclonic type scrubbers.

The S-F scrubber removes solids which adhere to scrubber walls. Where water supplies are limited heavy slurries can be recirculated and process materials can be recovered in concentrated form.

*

The Electric Reduction Co. of Canada (one of the Albright & Wilson group) are to build multi-million-dollar plants to produce sulphuric and phosphoric acids, as well as sodium phosphates and other products at Port Maitland, Ontario. Production should begin early in 1960.

*

New laboratory extensions to the research department of I.C.I. Alkali Division at Winnington, Cheshire, cover over 20,000 sq. ft. and increase the laboratory space by approximately a third. The three-storey building runs parallel with, and is connected to, the present block of research laboratories. Laboratories and offices are on one side only of the longitudinal corridors.

The ground floor houses semi-technical and development stages, and the two upper floors, which accommodate about 60 graduate scientists and their assistants, allow some flexibility in layout, *e.g.* benches can be resited without interfering with service outlets and can be replaced with special equipment.

It was at the main laboratories at Winnington that polythene was discovered by R. O. Gibson in 1933.

*

An extension to their works is announced by Associated Metal Works (Glasgow) Ltd., who report that the demand for stainless-steel products continues to grow, and that coupled with this there is an interest in larger and heavier equipment fabricated with stainless steel or aluminium. The new extension, to be completed soon, will enable the company to undertake production of this heavier equipment.

*

Ashmore, Benson, Pease & Co. have recently concluded a licence arrangement with the Mond Nickel Co. Ltd. enabling them to supply S.G. or high-ductile iron castings in accordance with British Standard Specification 2789 : 1956.

Ashmores have been offering high-duty iron castings made by the *Meehanite* process for 25 years; they will now be able to extend their foundry services by supplying grey iron, *Meehanite* iron and spheroidal-graphite iron castings in weights up to 25 tons in floor, loam, machine-moulded and CO_2-moulded castings.

Orders and Contracts

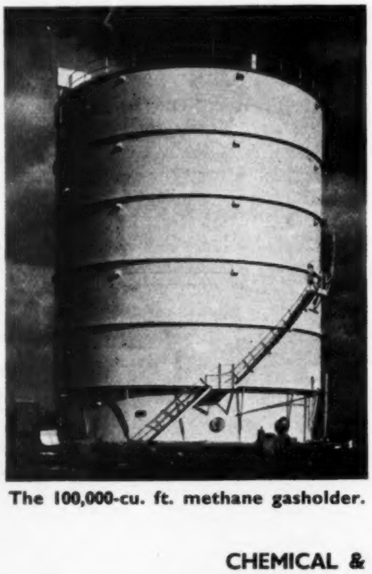
A 100,000-cu.ft. Wiggins' dry-seal gasholder has recently been completed by Ashmore, Benson, Pease & Co. for the North Thames Gas Board at Canvey Island. It will be used in connection with the large-scale experiment, mentioned in CHEMICAL & PROCESS ENGINEERING, March (page 80), for importing methane in liquid form from across the Atlantic.

The holder will store the gaseous bleed-off from liquid methane storage tanks.

*

Work has begun on the construction of the pipeline which will take effluent from the Atomic Energy Establishment at Winfrith Heath, Dorset, into the sea at Arish Mell. It will run for five miles overland from Winfrith and for about a further two miles out to sea.

Constructors John Brown Ltd. have been awarded the contract for the first four miles of the overland pipeline from the site boundary. Taylor Woodrow Construction Ltd. have been awarded the contract, in association with Collins Submarine Pipelines Ltd., for the remaining mile of overland pipeline and for the undersea section, which it is believed will be the longest underwater outfall to be constructed in Britain.



The 100,000-cu. ft. methane gasholder.

*

For chlorine and caustic soda production, the Travancore Cochin Chemical Co. have placed an order for a 27,500-amp. 120-v. rectifier equipment with Westinghouse Brake & Signal Co. Ltd. Silicon diodes will be used and water cooling has been chosen as preferable, and diodes being mounted on heavy copper bars which are cooled by distilled water recirculated through a heat exchanger to river-water.

The contract covers the a.c. circuit breaker for the 22-kv. input, a regulator, step-down transformer, the rectifier cubicle and the control panel which utilises automatic constant current control.

*

Completion of a 150-tons/day ammonia plant for Coastal Chemical Corporation at Pascagoula, Mississippi, is announced by Chemical Construction (G.B.) Ltd. The company reports that, during 1958, the number of Chemico ammonia plants completed, under construction or under contract totalled 12 (five in North America, four in Japan, two in France and one in East Pakistan).

Another member of the Chemico group of companies, Chemical Construction (France) Ltd., has recently been formed.

Personal Paragraphs

★ **Mr. E. Le Q. Herbert** has been nominated president-elect of the Royal Institute of Chemistry for 1959-61. A well-known chemical engineer, Mr. Herbert is managing director of Shell Refining Co. Ltd. and a director of Shell Chemical Co. Ltd., Trimpell Ltd., and Associated Ethyl Co. Ltd. He joined the Shell Group in 1927 as a plant chemist and served for nearly 12 years in Mexico before returning to the United Kingdom in 1938. He was appointed to his present position in July 1955.

Mr. Herbert.

★ **Mr. H. Smith,** joint managing director of I.C.I.'s General Chemicals Division for the past two years, has been appointed chairman. He joined I.C.I. in 1929 and held a number of appointments in the Dyestuffs Division. He became joint managing director of the General Chemicals Division in March 1957.

★ I.C.I. have also appointed, as chairman of the Paints Division, **Mr. E. J. Callard,** joint managing director of that division since 1955. His early service with I.C.I. was in the oil works and chief engineer's department, Billingham. He joined the Paints Division board in 1951.

★ Following the change of control of the British Aluminium Co. Ltd., **Lord Portal** and **Mr. G. Cunliffe,** chairman and deputy chairman respectively, have left the boards of that company and all its subsidiary and associated companies. **Sir Ivan Stedeford** has been elected a director and chairman of the board and **Mr. R. S. Reynolds** a director.

★ British Aluminium also announce that, on the retirement of **Mr. H. W. L. Phillips** next September, the following staff changes will be made at the research laboratories, Chalfont Park: **Mr. A. C. Coates** will become assistant director of research (chemical) and will deputise for **Dr. Pearson** in the latter's absence. **Mr. P. C. Varley** will be assistant director of research (metallurgical), **Dr. C. E. Ransley** will be senior research metallurgist and **Dr. F. A. Champion** will be senior research chemist.

★ **Mr. C. B. Evans** has been appointed to the board of Midland Silicones Ltd. He joined the company in 1955 as works manager at Barry. He was previously production manager for Peter Spence & Sons Ltd., and before that was for 13 years with the General Chemical Division of I.C.I.

★ **Mr. R. A. Le Page** has been appointed managing director of Mancuna Engineering Ltd.

★ **The Earl of Halsbury** joins the board of Lancashire Dynamo Holdings Ltd. as vice-chairman. He relinquishes his appointment with the National Research Development Corporation.

★ **Mr. E. W. M. Fawcett,** technical director, and **Mr. H. P. P. Hodgkins,** commercial director of Howards of Ilford Ltd., have been appointed to the board of the parent company, Howards & Sons Ltd.

★ **Mr. A. Whitfield** has taken over as general manager of Widnes Foundry & Engineering Co. Ltd. He joined the company in 1938, became works manager in 1949 and was appointed a director in 1955. **Mr. R. Credland** retires as joint managing director, but will remain on the board in a consultative capacity.

★ **Mr. G. W. I. Nokes,** general manager of Peabody Ltd., died recently, aged 54 years. He joined the company in 1945 as senior sales engineer. Previously he was technical adviser to the works manager of Berry Wiggins Ltd. at Kingsnorth, Kent. His earlier experience was gained as engineer on a tea plantation in Assam and later as shipping superintendent to the Medway Oil & Storage Co. at the Isle of Grain.

★ **Mr. D. P. Prestwich** has joined the board of Normand Electrical Co. Ltd.

Technology Notebook

Chemical engineering in Spain

Prof. D. M. Newitt, F.R.S., recently visited Spain at the invitation of the director of the Instituto Quimico de Sarria, Barcelona, to discuss the training of chemical engineers. The Institute has recently installed new plant, the first of its kind in Spain, for the practical training of students in standard operations involved in the chemical industry. They asked for the services of an experienced British teacher in chemical engineering who could discuss the best ways of using the new equipment.

Prof. Newitt, head of the department and Courtauld Professor of Chemical Engineering at the Imperial College of Science and Technology, London, has been responsible for a large expansion in training facilities for undergraduate chemical engineers at the College. He is a past-president of the Institution of Chemical Engineers.

Consulting scientists

A body to be known as the Association of Consulting Scientists has been formed in the United Kingdom to act as a clearing bureau for enquiries for independent scientific services. Membership embraces independent whole-time consulting scientists in all fields of science and technology other than medicine and civil, mechanical and electrical engineering. The founding members are mostly chemists and biologists, but physics and other sciences are expected to have representation before long.

The association will operate in close collaboration with the Royal Institute of Chemistry and other professional institutes, and with other organisations concerned with the co-ordination of British efforts in research, production and marketing.

The chairman is Dr. J. G. Davis and the honorary secretary Mr. W. H. Stevens, who should be addressed at 15 Hawthorne Road, Bromley, Kent.

Up-to-date oil research

A large extension to Wakefield-Dick's laboratories at Hayes, Middlesex, is equipped with modern apparatus for research on lubricating oils and allied products. Apparatus for the spectrographical analysis of the metallic constituents of oil samples, and radioactive isotopes for research purposes, are included, while, in the organic laboratory, each chemist is provided with separate compressed-air, gas, vacuum and nitrogen supply points and a high-velocity extraction system removes odorous fumes at bench level.

Change of title

Incorporated Plant Engineers has changed its name to the Institution of Plant Engineers.

World News

ISRAEL

Carbide production

Calcium carbide and calcium cyanamide are being produced in a factory recently opened at Petah-Tikva by Mayer Chemical Industrial Ltd. The main furnace of the plant is capable of operating at temperatures over 2,000°C. and annual output is estimated at 10,000 tons, of which at least two-thirds is intended for export. The establishment of this factory is a step towards rendering the Israeli plastics industry independent of imported raw materials.

Phosphorus project

Erection of a I£20-million phosphorus plant in Dinmoa by the Koor Co. has been approved, according to a report from Barclays Bank D.C.O. in Jerusalem.

The plant will employ some 200 workers and will require about 250,000 tons of phosphate. In the initial stages it should be able to produce I£2-million-worth of phosphorus.

RHODESIA

Industrial projects

A new factory with a minimum capacity of 50,000 tons p.a. of fertilisers is to be built in Salisbury, Southern Rhodesia, by Windmill Fertilizers Rhodesia (Pvt.) Ltd. The cost of the plant is estimated at £150,000.

Also in Southern Rhodesia, investigations are being made into the possibilities of erecting a fertiliser factory at Umtali, using wood and abattoir wastes as the starting materials.

In Northern Rhodesia, extensive reconstruction is being planned by Northern Rhodesia Lime Co., near Ndola. This £500,000 project includes a modern factory and an expansion of quarrying activities.

GREAT BRITAIN

Acrylonitrile

A plant for the manufacture of acrylonitrile from acetylene and hydrogen cyanide is being constructed by the I.C.I. General Chemicals Division at its Cassel works, Billingham. It is claimed that this will be the first large-scale plant of its kind in the world. It is expected to go into production towards the end of the year.

Main outlet will be for the production of acrylic fibres and high-impact-strength resins, but some of the acrylonitrile will be used within the I.C.I. organisation in the manufacture of *Butakon* synthetic rubbers.

'Udex' plant at Stanlow

A *Udex* unit, the first of its kind in any Shell refinery, has been brought into operation at Stanlow refinery, Ellesmere Port, for the production of an important aviation gasoline blending component. Construction of this £800,000 unit began at the end of 1957. It includes six columns, the tallest a 120-ft. solvent stripper, and has a capacity of 1,000 tons/day.

Designed by Universal Oil Products Co., U.S.A., the *Udex* unit is of the solvent-extraction type using a special solvent mixture of di-ethylene glycol, di-propylene glycol and water. The feedstock, which is a product of the Stanlow *Platformer*, will be extracted with this glycol mixture which preferentially dissolves the aromatic components of the feedstock. The aromatic extract is distilled off from the solvent and used in aviation gasoline, whilst the insoluble non-aromatic portion, or raffinate, will be used as an additional feedstock for other processes.

UNITED STATES

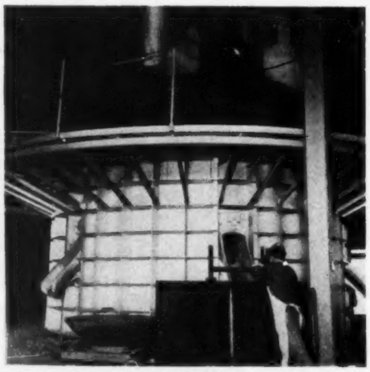
New synthetic rubbers

Two new synthetic rubbers, extended with 50 parts oil, which can be processed easily on standard rubber processing equipment, have been introduced by the chemical division of the Goodyear Tire & Rubber Co.

Ammonium perchlorate expansion

Pennsalt Chemicals Corporation plans to expand by several thousand tons the capacity of its recently completed ammonium perchlorate plant at Portland, Oregon. There will also be a 25% increase in capacity for the adjacent sodium chlorate unit which provides the principal raw material. Total investment will amount to some $2 million.

Ammonium perchlorate is used as an oxidiser for high-energy solid-state missile propellants.



The main furnace of the Mayer calcium carbide plant, Petah-Tikva, Israel.

HOLLAND

Acrylic fibre plant

A multi-million-dollar plant to manufacture *Orlon* acrylic fibre will be built at Dordrecht by the Du Pont Co. and operated by a subsidiary that will be formed shortly in the Netherlands. It will have a capacity of approximately 15 million lb. p.a.

Construction work will begin later this year, and start-up of operations is scheduled for the last quarter of 1961.

PORTUGAL

Synthetic resins

The new synthetic resin plant Resintela (Resinas Sinteticas Lta.) was officially inaugurated at Mato da Charneca, Mem Mantins, recently and production of a number of Reichhold resins is in progress. It is planned to add basic chemicals to the production line.

This undertaking is international in structure, having as partners American, Belgian, British, German and Portuguese. The companies interested in Resintela are: Companhia Geral de Combustiveis S.A.R.L., Sociedade Central de Resinas, Sepulchre Lta., Sociedade Comercial de Resinas and Reichhold Chemie A.G.

POLAND

Copper and acid

Construction of a copper works and a sulphuric acid factory is being carried out in Legnica in Lower Silesia. The copper works was due to begin operation last month. The sulphuric acid factory will process the bisulphurite obtained from smelting copper. It will be put into operation in the second quarter of this year and annual production of 20,000 tons is predicted. Plans and material for these works were supplied by the Soviet Union.

Atomic power

Poland's first atomic power plant is scheduled for completion by 1965. It will work on natural uranium and its capacity will probably be 200 Mw., but this has not yet been finally decided. Other plants, with a total capacity of 600 Mw., will be constructed between 1965-70, and between 1970-75 plants with a total

capacity of 1,000 Mw. will be completed. Thus by 1975 about 10% of all electricity produced in Poland will be provided by atomic power.

U.S.S.R.

Labour award

The Stalinogorsk Chemical Works in the Tula region received the Order of the Red Banner of Labour for its fulfilment ahead of schedule of assignments for putting production facilities into service, developing a new method of making nitrogenous fertilisers from natural gas, and for high output. This works was the first in the U.S.S.R. to start producing fertilisers last year using Stavropol natural gas as raw material.

FINLAND

Titanium oxide plant

The state-owned company, Vuorikemia Oy, is to erect a titanium-oxide plant at Pori, with a capacity of 16,000 tons p.a. The plant is expected to be operating in about two years' time. Orders for over half of the machinery needed have been placed in Finland. A new sulphuric acid plant to supply raw material will commence operations in 1960.

AUSTRALIA

Research centre

Plans for the erection of a research centre in Melbourne, to speed up the development of the Australian petrochemical industry, have been outlined. The centre, where scientists will be trained and research into chemical by-products of oil widened, is to be associated with a £A4-million synthetic rubber plant now being constructed near Melbourne by the Goodrich organisation of America and the Ampol Petroleum Co.

This factory, initially designed for producing motor tyres, will be expanded later to manufacture synthetic rubber products for industry, including tubing, matting and conveyor belts. It is expected to start operations early in 1960, with an initial output of 1,100 motor tyres daily.

Lead and zinc smelter

Work is to start soon on a lead and zinc smelter at Cockle Creek, in south-western New South Wales, as part of Consolidated Zinc Corporation Ltd.'s expansion programme. The company plans to spend £A8 million on the smelter and associated plant, which will include a big sulphuric acid works that will contribute to the manufacture of superphosphates. It is expected to have an annual output of about 38,000 tons p.a. of slab zinc and a similar amount of lead.

FRANCE

New petrochemical complex

A new complex of chemical plants has been brought into operation by Société Anonyme des Produits Chimiques Saint-Gobain at their plant at Berre, near Marseilles, adjacent to the oil refinery of Compagnie de Raffinage Shell-Berre. The new facilities will enable Shell Saint-Gobain, in which the Royal Dutch/Shell group of companies has a 60% interest, to manufacture *Epikote* resins and base materials for carbon black and detergents, as well as to expand their range of organic solvents.

Berre is becoming an increasingly important industrial centre. It is here that the Société des Elastomères de Synthèses, a joint company formed by Shell Saint-Gobain, Texas Butadiene and Chemical Corporation (an associate of Godfrey L. Cabot, Boston), Michelin, Kleber Colombes and Dunlop, are erecting a plant for the manufacture of 50,000 tons p.a. of styrene/butadiene synthetic rubber, which is expected to begin production in 1961.

PAKISTAN

Dyestuffs plant's progress

The Pak dyestuff chemical factory, a project of the Pakistan Industrial Development Corporation under construction at Daud Khel, is nearing completion. It is claimed that this factory will not only meet local demand but will also form the nucleus of an organic chemical industry in Pakistan, and a saving of Rs. 15 lakhs a year in foreign exchange is expected. A German firm has a 30% investment in the project.

INDONESIA

New projects

A superphosphate plant is to be built at Medan and talks have been held with a Soviet delegation on the erection of another fertiliser plant using coal instead of gas as its raw material.

A soap factory at Bireuen, North Sumatra, costing Rp.1 million and with an estimated output of 65 tons/month is reported to be nearing completion.

The Government is planning to build a gypsum plant in East Java with an output of 36,000 tonnes p.a. The national cement factories need 13,000 tonnes p.a. of gypsum to maintain production.

MEETINGS

Institution of Chemical Engineers

April 15. 'High Vacuum Technology in the Chemical Industry,' by A. S. D. Barrett and T. W. G. Rowe, 7.30 p.m., Blossoms Hotel, Chester. Joint meeting with Institute of Petroleum.

April 15. 'Electrical Engineering in the Chemical Industry,' by D. Birch, 6.30 p.m., College of Technology, Costa Green, Birmingham. Joint meeting with Chemical Engineering Group, Society of Chemical Industry.

Chemical Society

April 17. 'Explosion,' by S. Paterson, 5.15 p.m., St. Salvator's College, St. Andrew's.

May 1. 'Structure and Reactivity of Reduced Metallic Surfaces,' by Prof. K. W. Sykes, 4.30 p.m., Birmingham University.

May 1. 'Chemical Effects Due to Fission Fragments,' by R. Spence, 5.15 p.m., St. Salvator's College, St. Andrew's.

Institution of Mechanical Engineers

April 10. 'Canadian Atomic Energy Development,' by W. B. Lewis, 6 p.m., 1 Birdcage Walk, Westminster, London, S.W.1.

Society of Instrument Technology

April 15. 'Instrumentation of Open-Hearth Furnaces,' by C. Holden, 7.30 p.m., Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough.

April 16. 'Self-Optimising Control System for a Certain Class of Randomly Varying Inputs,' by A. P. Roberts, 5.30 p.m., Mansion House, Portland Place, London, W.1.

Institute of Metals

May 7. 'Electric Melting Furnaces,' by F. S. Leigh, 7.30 p.m., The University, Leeds 2.

Comical Engineering Corner

'WELL, YOU SEEM TO HAVE FOUND THE CAUSE, PIRBRIGHT — NOW FOR THE CURE'

Recent British Patents

Improved filter presses

The object of the invention is the automatic opening of the trays (plates) of a filter press so that the operator need take no action to couple them to the travelling members. The means for doing this comprise an endless chain, or similar driving device, having latch members attached thereto. The latter engage with projections on both sides of the trays, but this occurs only when any one plate or plates is, or are, not in a predetermined or abutting relationship with two plates having projections thereon. The latch members consist of drop arms having hook-shaped ends to engage the projections of the trays. The trays, when packed tight in the closed position of the press, are so spaced that the distance between the projections on adjacent trays causes the latch arms to be supported so that they cannot become engaged with the projections.

The latch arms, which are levers, have cam faces on the under sides. The spacing of the cam faces and the hook-shaped ends of the latch arms corresponds with that of the projections on the trays in the closed position. When a latch arm is about to pass beyond the end tray of a closely packed series, it becomes unsupported, and drops automatically so that the hook end engages the projection of the end tray. Disengagement is similarly automatic when the tray has been drawn to a position at the other end of the guide rail. The invention is illustrated by three sheets of drawings appended to the specification. — 804,865, *The Associated Portland Cement Manufacturers Ltd.*

Foundry moulds and cores

Outstanding merits are claimed for new self-binding agents for casting moulds and cores, especially for use in steel foundry work. The binding agent, which is mixed with sand, consists of one or more drying oils, such as linseed oil, one or more oil-soluble phthalates or maleates of glycerol or pentaerythritol, and at least one siccative. The addition of the siccative is stated to convert an otherwise unsatisfactory combination of drying oil and synthetic resin into a product of great utility. No individual siccative is named in the specification. Advantages claimed for the new binding agents are a slow rate of burning out, and the fact that they may be used with moist quartz sand, or a mixture thereof with moulding sand which contains clay. If the foundry cores are to withstand large stresses, it may be advisable to substitute zircon sand for quartz sand.

In the single example of the specification, the binding agent consists of 50 parts of linseed oil, 45 parts of glycol maleate resin, and 5 parts of a siccative solution. The ingredients are boiled together or separately to form a stand oil, which is the setting binder for a moulding composition consisting of 80 parts of quartz sand, 20 parts of moulding-sand, and 2 parts of the binder. — 803,397, *Dr. F. Raschig, GmbH.* (*Germany*).

Electrolytic oxidation of aluminium alloys

The object of the invention is the provision of electrolytically produced oxide coatings on the surface of aluminium alloys of the kind containing more than 3% of copper and more than 7% of silicon. Such alloys are used for sliding structural elements in machinery, *e.g.* pistons or cylinders of internal combustion engines, and require outstandingly hard and strong surfaces.

The alloys are degreased and then pickled, in the usual manner, in a bath of nitric acid or mixed nitric and hydrofluoric acids. Before the electrolytic treatment, which is conventional, the rough surfaces created by pickling are smoothed mechanically, this operation removing substances which would prevent the formation of a durable surface. After the electrolytic oxidation, no finishing operations are required.

It is sometimes necessary to remove hydrogen formed during the pickling, as it is not eliminated during the electrolytic process, and may be detrimental. The articles are heated at 200°C. for from 1 to 3 hr. before the step of smoothing or compacting. — 803,357, *Karl Schmidt GmbH.* (*Germany*).

Brazing alloys containing cobalt

For brazing or joining honeycomb cores made of stainless steel, nickel-base brazing alloys are commonly used. Such an alloy is '17-7PH,' which is a stainless steel, hardenable by heat treatment, and of great strength. It consists of 17% chromium, 7% nickel, less than 0.08% carbon, about 1% aluminium, and the balance iron. It is stated that in brazing the very thin steel of honeycomb structures, the alloy diffuses into the ferritic base alloy, forming stable austenite. This causes stresses due to different coefficients of expansion of the austenite and the unchanged ferrite.

It is claimed that the addition of cobalt to nickel-base brazing alloys reduces the aforesaid diffusion, and results in stronger structures. The alloy is also suitable for brazing base metals containing cobalt, and its melting point is not materially affected by the introduction of cobalt.

The preferred composition of the alloy containing cobalt is less than 0.1% carbon, 70% nickel, 20% cobalt, 3% boron, and 4.5% silicon or, alternatively, less than 0.1% carbon, 60% nickel, 20% cobalt, 3% boron, 4.5% silicon, 7% chromium, and 3% iron. — 803,253, *Coast Metals Inc.* (*U.S.A.*).

Removing organic sulphur from gases

Sulphur compounds, other than hydrogen sulphide, present in industrial gases such as coal gas, water gas, and the like, are designated 'organic sulphur.' In this patent, the organic sulphur is converted catalytically to hydrogen sulphide, which is removed by known methods. The catalyst consists of copper chromite on alumina, over which the gases are passed at 250 to 270°C., at a 'space velocity' of 250 to 350 volumes/hr. per unit volume of catalyst. The catalyst is regenerated by passing oxygen through it for an hour at the rate of 200 volumes to one volume of catalyst.

To prepare the catalyst, 4 lb. of commercial copper sulphate and 2 lb. of commercial sodium dichromate, both of about 20 mesh size, are dissolved in 16 to 20 lb. of water; ½ lb. of ammonia is slowly added. A complex salt is precipitated. The liquid is filtered and the precipitate dried at 110°C. in an air oven to a moisture content of 5%. The filter cake is then powdered and mixed intimately with 2.3 lb. of alumina. By means of a pelleting machine, the mixture is formed into pellets of 5 to 6 mm. diameter and 2 to 3 mm. thick. —803,399, *Council of Scientific and Industrial Research* (*India*).

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